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WILLIAM H. WESTON, JR., FIRST PRESIDENT OF THE MYCOLOGICAL SOCIETY OF AMERICA

FREDERICK A. WOLF

(WITH PORTRAIT)

There is little room in the field of science for the operation of the laws of chance. Those events that transpire are rather the resultant of definite causes, admittedly little known or little understood in many cases, but yet they are not merely fortuitous. This is preëminently true in the case of events leading up to and including the birth and establishment of the Mycological Society of America. This organization is in no sense an example of spontaneous generation. Its inception required the presence of a man of the hour. Such a man had to be gifted with the powers of visualizing the benefits that would accrue, in increasing proportions down through the years, to the whole field of mycology if such an organization were in existence, had to be endowed with that accuity and diplomacy so essential for catalyzing and amalgamating sentiment into one concrete unit, and had to be imbued with that dynamic, irresistible, coöperative leadership that carries plans to consummation. This type of personality, this manner of man is the first president of the Mycological Society of America, Dr. William H. Weston, Professor of Cryptogamic Botany, Harvard University. Those who labored with him shoulder to shoulder in this endeavor will comprehend Professor Weston's evaluation of his own efforts in organizing the Mycological Society of America from his characteristic phrase " there wasn't much grief in it."

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Properly to appraise the work and influence of a mycological colleague while he yet lives is so difficult as to be almost impossible. A portion only of the qualities for which he may be appraised may be accounted for by the fact that he was trained by such outstanding scholars, teachers, and investigators as Prof. W. G. Farlow and Prof. Roland Thaxter, his predecessors in the same post. Another portion comes from his experiences in mycological and plant pathological investigations that have carried him to the Philippine Islands, Guam, Hawaii, Cuba, and to various parts of the United States. So far as science is concerned these experiences have resulted in a series of studies on the Phycomycetes, primarily on the downy mildews.

In order really to know "Cap," as he is affectionately denominated by those associated with him, one must listen to him in the lecture room as he fluently and enthusiastically presents his materials with a clarity that is intriguing because he never seems to lack for the most acceptable word. From this exactitude in correctness of expression he may suddenly lapse into the use of some current slang so that the student never forgets the point in question. One must also see him daily as he gives unstintingly of his time, experience, and energy in heaping measure to associates and students. If he tires of their numerous intrusions into his office and laboratory to seek counsel, suggestions, references to literature pertinent to their problem, criticisms of experimental procedure, results, or manuscripts, or if he is irritated by them, there are no "external symptoms" of it. His patience, which is monumental, fortified by an unusually keen sense of humor, and his ability to inspire all who come under his influence are an unusual combination of traits that will result in the training and development of a corps of mycologists who will share in the continued enrichment of our knowledge in the field of mycology, and will be an honor to the Mycological Society of America.

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RHOPOGRAPHUS ZEAE ON CORN

R. K. VOORHEES

(WITH PLATES 15 AND 16)

In the spring of 1893, Patouillard [1] reported a species of *Rhopographus* on cornstalks on the ground at Pululahua, Ecuador, which he described under the binomial *Rhopographus Zeae*. Later this description was listed by Saccardo [2] and was emended by Sydow.[3] Aside from these, no other report of this species has been found in the literature. The original description is as follows:

"*Rhopographus Zeae* Pat. nov. sp.—Sur des tiges de mais, a terre. Pululahua. Fevrier. Stromatibus parallelis, linearibus, hysteriiformibus, ½–3 mm. longis, nigris, per rimas parallelas erumpentibus, intus albis; loculis 2–5, vix ostiolatis, connatis, sphaeroideis; ascis clavato-cylindricis, indistincte paraphysatis, 8-sporis (100–150 × 20 μ); sporidiis distichis, fusiformibus, utrinque acutis, melleis, primitus, 1, dein 3, denique 5-septatis, medio constrictis, uno loculo saepe inflatis (33–40 × 6–7 μ)."

In 1928, A. H. Eddins and Erdman West of the Florida Agricultural Experiment Station collected a species of *Rhopographus* on old cornstalks near Gainesville, Florida, which was identified by the latter as *Rhopographus Zeae* Pat. (No. *4770*—Fla. Agr. Exp. Sta. Herb.), but the collection was not reported. During the past three seasons, the writer has found this fungus occurring commonly on old cornstalks in the vicinity of Gainesville.

The *Rhopographus* on corn in Florida agrees with the description of Patouillard, except that thread-like paraphyses are quite distinct (PLATE 15, FIG. 2) and the limits in dimensions of the ascospores of the Florida organism exceed those of his fungus. The ascospores of the Florida fungus measure 30–52 × 6–10 μ, while those of *R. Zeae* as described by Patouillard measure 33–40 × 6–7 μ. In obtaining the dimensions of the spores of the Florida

[1] Patouillard, N. & G. von Lagerheim. Champignons de l'Equateur. Bull. Soc. Myc. **9**: 156–157. 1893.

[2] Saccardo, P. A. Syll. Fung. **11**: 378. 1895.

[3] Sydow, H. Ann. Myc. **13**: 427–428. 1915.

Rhopographus 200 ascospores from material fresh from the field were measured. The parallel, hysteriform stromata are shown in plate 15, figure 1. A typical clavate-cylindrical, 8-spored ascus is shown in plate 15, figure 3. The pointed 1, 3 and 5-septate ascospores, constricted in the middle with one cell frequently swollen are shown in plate 15, figure 4. These spores germinate from both end cells, as shown in plate 15, figures 5, 6, and 7.

No mention was made of a vegetative stage in Patouillard's description of this fungus. However, according to Sydow [4] "the context of the stromata is composed of almost hyaline, delicate, brittle, vertically parallel hyphae 4 μ thick; only the crust above, below, and on the sides is formed of more compact, dark, brownish-olive colored hyphae 12–15 μ thick; on the sides and base these hyphae penetrate between the cells of the matrix." These characters were also observed in the Florida fungus but the hyphae did not exceed 6 μ in diameter.

No report of an imperfect stage of this fungus has been found in the literature, neither has this stage been found on host material in Florida. However, an imperfect stage was produced in culture by planting single ascospores of *R. Zeae* (No. *8057* Fla. Agr. Exp. Sta. Herb.) in petri dishes and test tubes containing corn meal agar. This imperfect stage is typical of the genus *Clasterosporium* Schweinitz. Two species of *Clasterosporium* have been reported on corn. In 1893, Ellis and Everhart [5] named a fungus from corn as *C. olivaceum,* but Saccardo [6] had previously classified another fungus under this binomial. To avoid the confusion of having two different fungi under the same binomial, Saccardo and Sydow [7] renamed Ellis and Everhart's fungus *C. Zeae,* indicative of its host. Saccardo [8] also described another *Clasterosporium* from corn and named it *C. maydicum.*

Since the *Clasterosporium* described in this paper does not correspond with the description of either of the above species, it is considered new and is described as follows:

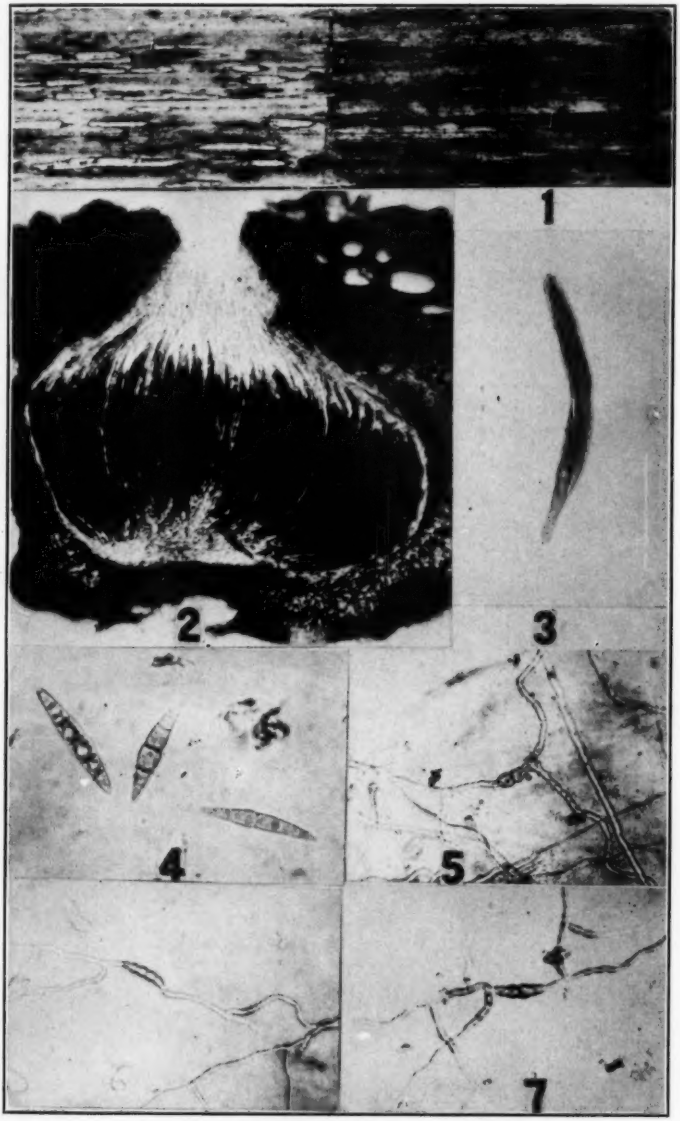
[4] Loc. cit.

[5] Ellis, J. B. & B. M. Everhart. New species of fungi from various localities. Proc. Acad. Nat. Sci. Phila. **45**: 440–466. 1893.

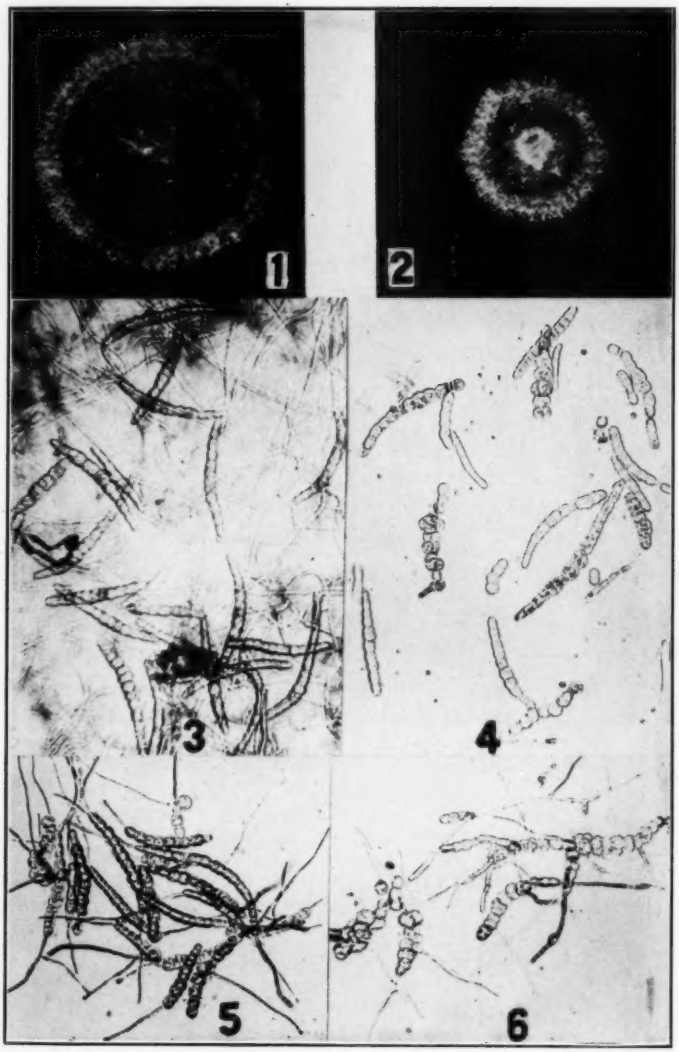
[6] Saccardo, P. A. Syll. Fung. **4**: 382–394. 1886.

[7] Saccardo, P. A. & H. Sydow. Syll. Fung. **14**: 1082–1083. 1899.

[8] Saccardo, P. A. Syll. Fung. **25**: 805–809. 1929.



RHOPOGRAPHUS ZEAE



RHOPOGRAPHUS ZEAE

Clasterosporium longisporum sp. nov. Mycelium in culture low, medium dense, wooly, almost hyaline, several septate, slightly constricted at septa, frequently anastomosing, 3–5 μ thick; conidiophores short, solitary, slightly darker than hyphae, frequently septate; conidia acrogenous, solitary, elongate, straight or slightly curved, fusoid, muticate, pleuri-septate, constricted at septa, brownish-olive, measuring 70–120 $\times$ 8–20 μ; new cells frequently budding off from parent conidial cells, either of which may germinate (PLATE 16, FIGS. 3, 4, 5, 6).

Hyphae produced from single ascospores or conidia planted on potato-dextrose agar in petri dishes, grow slower than on corn meal agar (PLATE 16, FIGS. 1, 2). Hyphae produced from conidia planted on sterilized corn meal in petri dishes grow slower than on either kind of agar and the growth is higher and more dense.

No infection was produced by this fungus when corn seedlings, stalks and ears were inoculated with either an ascospore or conidial suspension of the fungus growing on corn or wheat kernels. Observations have shown that under natural conditions the fungus does not attack corn stalks until after they have matured. Consequently, no particular damage is caused by it.

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EXPLANATION OF PLATES

PLATE 15

Fig. 1. An enlarged portion of a cornstalk showing the parallel, hysteriform stromata, part of which is cut in half to show the white interior. $\times$ 7.

Fig. 2. A typical perithecium containing asci with thread-like paraphyses. $\times$ 325.

Fig. 3. A typical 8-spored clavate-cylindrical ascus. $\times$ 600.

Fig. 4. Typical pointed 1, 3 and 5-septate ascospores showing constriction in middle with one cell frequently swollen. $\times$ 700.

Figs. 5, 6, 7. One, 3 and 5-septate ascospores respectively, germinating at both ends on potato-dextrose agar. The 3-septate ascospore is shown just before becoming 5-septate (6). $\times$ 250.

PLATE 16

Figs. 1, 2. Single ascospore cultures growing on corn meal and potato-dextrose agar, respectively. $\times$ 2.

Figs. 3, 4. Typical conidia produced from single ascospore cultures growing on corn meal and potato-dextrose agar. Older conidia showing new cells budding off from parent conidial cells (4). $\times$ 250.

Figs. 5, 6. Germination taking place from parent conidial cells and from new cells budded off from parent cells. $\times$ 250.

SPORANGIAL GERMINATION IN THE GENUS MYZOCYTIUM [1]

G. E. THOMPSON [2]

(WITH 1 TEXT FIGURE)

While searching filaments of *Spirogyra* for members of the lower Phycomycetes, the thallus of a species of *Myzocytium* was found. The method of sporangial germination was later observed and proved to be at variance with those previously described for this genus, since no vesicle is formed at the tip of the exit tube. The zoöspores mature within the sporangium and escape successively in single file.

Thallus. In the young stages the thallus consists of an unbranched mycelial filament which is constricted at regular intervals to form a chain of ellipsoidal cells. At each constriction the narrow channel is plugged with a spherical refractive granule giving the aspect of a thick septum. This is probably a cellulin granule corresponding with those described for the genera *Gonapodya* and *Leptomitus.* Similar refractive granules are scattered throughout the cytoplasm. The individual cells of a mature thallus are oval to ellipsoidal and measure 16–26 × 13–16 μ. The number of cells in the chain varies from five to twelve.

Asexual reproduction. The cells of a chain may all function as sporangia, or as sporangia and male and female gametangia. Each sporangium germinates by a single exit tube, about 3 μ in width, which is slightly constricted where it passes through the host cell wall. At about the time that the exit tube penetrates the wall, the densely granular content of the sporangium rounds up to form small globose bodies showing a slightly oscillating movement. At first this movement is more noticeable towards the center of the mass. In a few minutes it is present in the entire contents of the sporangium. The protoplasm in the exit tube then

[1] Presented at the first meeting of the Mycological Society of America held in Atlantic City, New Jersey, December 28–30, 1932.

[2] The writer wishes to extend his thanks to Professor H. M. Fitzpatrick for many valuable suggestions and for his critical reading of this paper.

begins a definite flow towards its tip, the tip ruptures, and the zoöspores escape successively in single file. As the zoöspore is passing through the orifice of the exit tube its movements are of exceeding interest. It swings rapidly back and forth, each time pulling itself farther from the mouth of the tube. Once free it darts rapidly back and forth in the water. During its attempts to gain freedom a fine strand of protoplasm can be seen trailing out behind.

After most of the zoöspores have escaped, those remaining within the sporangium can be seen darting about until finally they find the way out. Usually all the cells functioning as sporangia germinate simultaneously.

Sexual reproduction. Two contiguous cells function as gametangia in sexual reproduction, one male, the other female. Fertilization is accomplished by the discharge of the contents of the male gametangium through a short terminal tube which penetrates into the female gametangium. No evidence of an oösphere was observed. Following fertilization the content of the female gametangium rounds up and assumes a thin wall to form a resting spore. Later the wall thickens and the globose resting spore, 13–16 μ in diameter, lies free within the female gametangium. It usually contains one or two refractive granules. Following fertilization the two sexual cells are readily distinguishable, the female gametangium being globose to spherical, while the male gametangium is somewhat pyriform.

Discussion. In the genus *Myzocytium* two sorts of sporangial germination have previously been described. In *M. proliferum* Schenk the contents of the sporangium pass out into a thin-walled vesicle in which the zoöspores are delimited. In *M. vermicolum* (Zopf) Fischer, according to Dangeard (**1906**: 210), the zoöspores are delimited within the sporangium and then a group of five or six zoöspores pass out into a vesicle which later breaks, freeing them. The remaining zoöspores then escape singly one after another from the sporangium.

The species described above corresponds most closely in its manner of sporangial germination to *M. vermicolum,* but shows variation in the fact that no vesicle is formed at the tip of the exit tube.

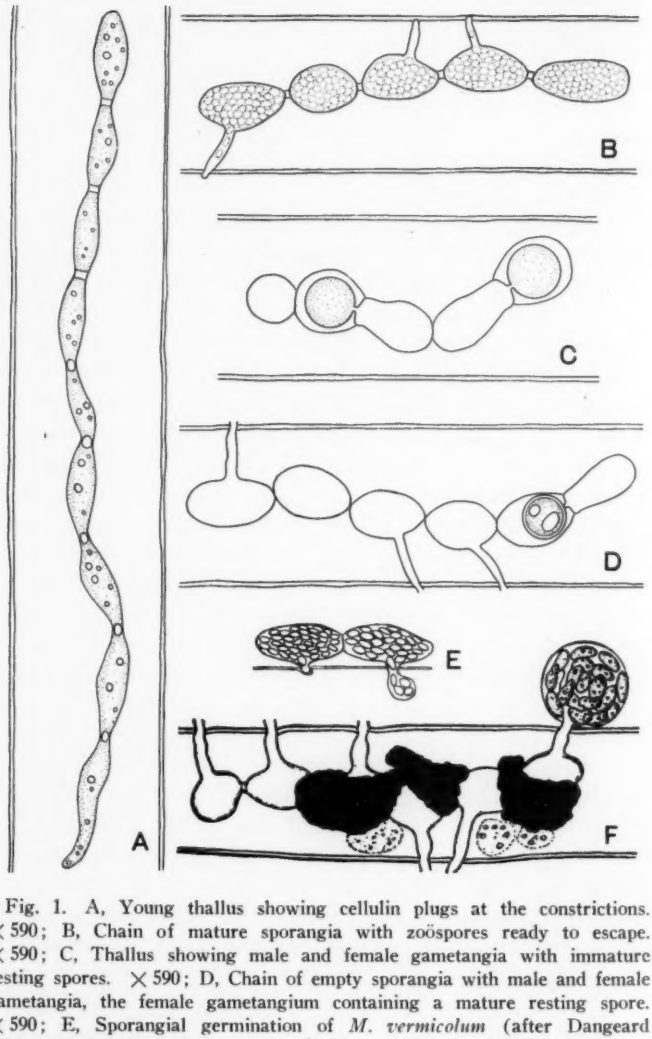

Fig. 1. A, Young thallus showing cellulin plugs at the constrictions. × 590; B, Chain of mature sporangia with zoöspores ready to escape. × 590; C, Thallus showing male and female gametangia with immature resting spores. × 590; D, Chain of empty sporangia with male and female gametangia, the female gametangium containing a mature resting spore. × 590; E, Sporangial germination of *M. vermicolum* (after Dangeard 1906); F, Sporangial germination of *M. proliferum* (after Zopf 1884).

The writer hesitates to describe this species as new, until he has obtained further information on its morphology and life history. The material was collected in a pond at the Fish Hatchery, Cornell University, during October 1932.

In another species of *Spirogyra,* material of *M. proliferum* was found. In it sporangial germination typical of *M. proliferum* usually occurred. In a few cases, the protoplasmic contents of the vesicle instead of differentiating into zoöspores, rounded up into two or three spherical bodies of varying size, which separated and moved away with a rolling motion. This observation recalls those of Atkinson (**1909**: 335–336) on *Lagenidium americanum.*

Myzocytium proliferum Schenk occurring in various members of the green algae has been reported in literature for America by Martin (**1927**: 188), Graff (**1928**: 168), and Sparrow (**1932**: 288).

Myzocytium vermicolum (Zopf) Fischer occurring in Anguillulidae has not been reported for America. In Europe, Dangeard (**1906**: 202) reports it as being quite common in the bodies of *Anguillules.*

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ANGIOPSORA, A NEW GENUS OF RUSTS ON GRASSES

E. B. MAINS[1]

(WITH PLATES 17–20)

While studying rusts from tropical America, specimens in the Herbarium of the University of Michigan labeled *Uromyces leptodermus* Sydow were examined. Among these a collection was found which was issued as no. *95* in the Reliquiae Holwayanae. The packet contains two leaves of *Lasiacis ruscifolia* (H. B. K.) Hitch. & Chase and is labeled as having only uredinia. Telia are, however, present in abundance (PLATE 17, *A*). They are small crusts which coalesce to form blackish areas 3–15 mm. long and 1–3 mm. wide. A careful search through other collections on *Lasiacis* resulted in finding also in *Uromyces leptodermus* another specimen bearing telia. This was collected on *Lasiacis divaricata* (L.) Hitch. at Utuado, Puerto Rico, 11–8–1915, by F. L. Stevens (*4608*).

Sections show that the telia of these collections are lenticular masses of cells covered by the epidermis. They are arranged in vertical columns up to three to four cells thick in the center of the sorus (PLATE 17, *B*). The cells may be separated from each other only with some difficulty. However, in a mount made by scraping with a scalpel they separate almost as easily vertically as laterally (PLATE 18, *B*). The compact, subepidermal, lenticular telia remind one very much of those of species of *Phakopsora*, *Bubakia* and *Schroeteriaster*. Species of these genera have not been described on grasses.

However, three species of *Puccinia*, *P. pallescens* Arth., *P. phakopsoroides* Arth. & Mains and *P. compressa* Arth. & Holw. (not *P. compressa* Diet.) have been described on grasses. These species agree with the rust on *Lasiacis* in many particulars. They all have subepidermal, compact, lenticular telia in which the telio-

[1] Papers of the Botany Department and University Herbarium, University of Michigan No. 435.

spores adhere together laterally. Pedicels are not evident in any of these species.

A comparison of these three species with the collections on *Lasiacis* show that they differ in several important respects. *Puccinia phakopsoroides* and *P. compressa* (PLATE 20, *B*) have well developed paraphyses bordering the uredinia, while a careful study of the rust of *Lasiacis* resulted in finding only a very few hyphoid paraphyses. In this respect the latter resembles *Puccinia pallescens*. *Lasiacis*, however, belongs in the Paniceae of the Poaceae, while Arthur and Fromme (**4**, p. 278) list species of *Tripsacum* and *Zea* belonging to the Tripsaceae as hosts of *Puccinia pallescens*. One would not expect the same species of rust on such fairly widely separated genera of grasses. The urediniospores of the rust of *Lasiacis* are somewhat larger (15–22 × 22–32 μ) than the measurements given by Arthur and Fromme for *Puccinia pallescens* (13–21 × 20–29 μ). Arthur (**2**, p. 111) states in his description of *Puccinia pallescens* that the urediniospores of the rust on *Zea Mays* are somewhat larger than those on *Tripsacum*. Through the kindness of Dr. Arthur it has been possible to study a specimen bearing uredinia and telia of this rust collected on *Tripsacum latifolium* Hitch. at Jinotepe, Nicaragua, November 3–7, 1911, by A. S. Hitchcock (*8720*). The urediniospores of this collection are decidedly smaller (12–16 × 18–25 μ) than those of the rust of *Lasiacis*. The urediniospores of the type of *Uredo pallida* Diet. & Holw. which Arthur gives as a synonym are also smaller (14–16 × 16–23 μ). A study of collections of *Puccinia pallescens* on *Zea Mays* received from F. J. Seaver, who collected them in Trinidad in 1921, gives measurements for the urediniospores of 16–20 × 23–30 μ. Since telia have not been found associated with the uredinia on maize it seems doubtful whether this rust on maize should be included in *Puccinia pallescens*. With *Puccinia pallescens* thus interpreted, the rust on *Lasiacis* differs in its larger urediniospores, more luxuriant development of the telia, and the genus of grasses infected. Apparently it is an undescribed species.

Although the three described species have been placed in the genus *Puccinia* their resemblance to species of *Phakopsora* has been noted (**5**), as is indicated by the name *Puccinia phakop-*

soroides. The addition of another species to this group has made it desirable to restudy the whole situation. Through the kindness of Dr. J. C. Arthur specimens showing the telia of *Puccinia phakopsoroides, P. pallescens* and *P. compressa* have been made available for study. A comparison of the four species shows that they all agree in having subepidermal, compact, lenticular telia in which the spores adhere laterally (PLATES 17, *B*; 19, *A, B*; 20, *A*). No pedicels could be detected. These are the principal characters by which the family Melampsoraceae is usually distinguished from the Pucciniaceae in which the teliospores are free and are borne on a pedicel. Dietel (**9**) has recently placed less emphasis on these distinctions. Although he considers that in general they determine the family he has placed a number of genera in which the teliospores lack pedicels and are more or less laterally adherent in the Pucciniaceae. However, it is generally considered that the genus *Puccinia* contains species in which the teliospores have pedicels and do not adhere laterally. Such species as *Puccinia rubigo-vera* (D. C.) Wint. and *Puccinia Elymi* Westen. have telia in which teliospores are arranged in a compact, more or less lenticular mass long covered by the epidermis. However, when scraped from the leaf and mounted in water, they readily separate from each other. In such species the vertical rows of cells forming the teliospores do not separate easily. In fact they break more easily above or below, rather than at the septa. Although the pedicels in these species are very short, there is no difficulty in detecting them. The species under discussion have telia without evident pedicels and with the spores adhering laterally almost as firmly as vertically. Although the cells of the telium are separable only with some difficulty when a mount is made by scraping with a scalpel, especially if crushed under a cover glass, they tend to separate into single cells (PLATE 18, *B*) indicating that the telia consist of one-celled, catenulate teliospores. They should not, therefore, be placed in the genus *Puccinia*.

As has already been indicated, these species have certain resemblances to species of the genera *Phakopsora, Schroeteriaster* and *Bubakia*, specially in the characters of the telia which have just been described. *Phakopsora* was described by Dietel (**6**, p. 276, **7**, p. 333) based on *Phakopsora punctiformis*. In the de-

scription of this rust, Dietel states that no paraphyses are present and makes no mention of peridia for the uredinia (**6**, p. 276). The telia are described as consisting of one-celled teliospores arranged in a number of layers but united in a lenticular body. Dietel emphasizes the manner in which the teliospores are developed, stating that the spores are not in definite rows but the younger spores are wedged up between the older. Magnus (**10**, p. 130) studied material furnished by Dietel and found both paraphyses and peridia in the uredinia.

Schroeteriaster was described by Magnus (**10**) based on *Schroeteriaster alpinus* (Schröt.) Magnus. Magnus describes the uredinia as without peridia or paraphyses and the telia as consisting of one-celled teliospores without pedicels. These are united together in a many-layered lenticular crust.

Bubakia was proposed by Arthur (**1**, p. 338) for those rusts with uredinia without paraphyses or peridia and with teliospores compacted into a subepidermal telium more than one layer thick. *Bubakia Crotonis* (Burr.) Arth. was selected as the type species.

A comparison of the four grass rusts with species of these three genera has resulted in the discovery of several important differences. Sections of uredinia of *Schroeteriaster alpinus* show that these have a broad, flat spore-bearing surface which is early exposed and only bordered by a slight fringe of ruptured epidermis. The urediniospores are borne on well developed pedicels. The uredinia of the grass rusts under discussion are much smaller, more or less covered by the epidermis which is irregularly slit and the pedicels are either very inconspicuous or absent. The telia of *Schroeteriaster alpinus* consist of one-celled teliospores fairly firmly compacted into lenticular crusts. A careful study of the telia has resulted in finding that the teliospores are not catenulate but are produced singly on pedicels. The pedicels are hyaline and very delicate and apparently are for the most part soon destroyed by the pressure of the crowded teliospores. They can be detected for the younger teliospores, specially when such develop near the margin of uredinia where they are not subjected to pressure. Occasionally pedicels can be traced downward from the teliospores in the upper part of the telium. The younger telio-

spores develop between the older and are pushed up between them and form a compact mass and separate with some difficulty.

Magnus (**10**, p. 131) considered that *Schroeteriaster* belonged in the Pucciniaceae close to *Uromyces*. The Sydows (**11**, p. 399), Arthur (**1**, p. 338), and Dietel (**8**, p. 548) have placed it in the Melampsoraceae close to *Phakopsora*. Dietel later (**6**, p. 84) considers it in the Pucciniaceae next to *Uromyces*. The presence of pedicels in the telia supports the latter arrangement. The genus is apparently monotypic and differs from *Uromyces* only in the compact lenticular telia with more or less adherent teliospores.

In many respects the uredinia of the grass rusts resemble those of *Phakopsora* and *Bubakia*. Unfortunately it has not been possible to study material of *Phakopsora punctiformis* Diet. but a comparison with *Bubakia Crotonis* (Burr.) Arth. and several species which have been placed in *Phakopsora* shows agreement in the presence of the overarching epidermis and the apparently sessile urediniospores.

However, the telia of the grass rusts show an important difference from those of these genera. Dietel in his description of *Phakopsora* emphasizes the fact that the one-celled teliospores are not catenulate but that the younger develop between the older and wedge in between them. A study of the type of *Bubakia* has resulted in finding a similar development for its teliospores. The younger spores apparently force the older upward in their development and by their adherence they form lenticular crusts. The grass rusts with their catenulate teliospores thus form a group which differs sufficiently to be considered a separate genus. For this the name *Angiopsora* is therefore proposed.

Angiopsora gen. nov.

Uredinia minuta, subepidermalia, diu tecta, praedita paraphysibus aut nullis; urediniosporae echinulatae, solitariae, sine conspicuis pedicellis. Telia subepidermalia; teliosporae coloratae, leves, unicellulares, catenulatae, 2–4 superpositae, stratum compactum lentiforme formantes, catenulis lateraliter arcte coalitis, sine pedicellis.

Species typica: *Angiopsora lenticularis*.

The rust on *Lasiacis* is an undescribed species and for it the name *Angiopsora lenticularis* is proposed.

Angiopsora lenticularis sp. nov.

II. Urediniis amphigenis, minutis 0.2–0.4 mm. subepidermalibus, diu tectis; urediniosporis sessilibus, ellipsoideis vel obovoideis, 15–22 × 22–32 μ, membrana tenui praeditus, 1–1.5 μ, echinulatis, poris inconspicuis.

III. Teliis hypophyllis, minutis, 0.2–0.3 mm., atro-brunneis, aggregatis in macula 3–15 mm. longa, 1–3 mm. lata; teliosporis variabilibus, angulatim ellipsoideis vel oblongis, 11–16 × 16–32 μ crassis, ad apicem leniter incrassitis, 2–4 μ, flavo-brunneis, sine pedicellis.

Lasiacis ruscifolia (H. B. K.) Hitch. & Chase, Guayaquil, Ecuador, July 31, 1920, E. W. D. and Mary M. Holway, (*801*) Reliq. Holw. *95*. II III, type.

Lasiacis divaricata (L.) Hitch. Utuado, Puerto Rico, Nov. 8, 1915, F. L. Stevens, (*4608*) II III.

The collection on *Lasiacis ruscifolia* has abundant telia which in many cases coalesce to form conspicuous blackish areas (PLATE 17, *A*). The telia on *Lasiacis divaricata* are few and scattered probably indicating that the formation of telia had just started when the collection was made. Otherwise the two collections are very similar. As indicated by plate 17, *B* the teliospores show no evidence of pedicels. The catenulate arrangement of the teliospores is responsible for a certain resemblance to those of *Puccinia*. However, as has already been discussed, the separation of cells of the telium when crushed indicates that each cell should be considered a teliospore (PLATE 18, *B*).

The uredinia are more or less bullate (PLATE 18, *A*) and the overarching epidermis is ruptured as a more or less irregular slit. A careful study indicates that thin-walled, hyphoid paraphyses are occasionally formed but these are so few and difficult to find that they are of little value as a diagnostic character. In sections of the uredinia, some evidence was found of a fungal tissue immediately beneath the overarching epidermis. From dried herbarium specimens it is difficult to determine its nature since it apparently is soon compressed by the pressure of the developing urediniospores. It appears to be a thin layer of hyphae and probably is responsible to some extent for the persistence of the overarching epidermis. It possibly may be the remnant of a delicate thin-walled peridium.

The three species belonging to this group of rusts which have been assigned to *Puccinia* should be transferred to the genus *Angiopsora* with the following modifications.

Angiopsora pallescens (Arth.) comb. nov.

Uredo pallida Diet. & Holw.; Holw. Bot. Gaz. **24**: 37. 1897.
Puccinia pallescens Arth. Bull. Torrey Club **46**: 111. 1919.
Dicaeoma pallescens Arth. & Fromme, N. Am. Flora **7**: 276. 1920.

As already stated, Arthur and Fromme have included a tropical *Uredo* on maize in this species. This has larger urediniospores than the rust on *Tripsacum* and should be excluded until telia are found by which it may be properly placed. As here interpreted the urediniospores are 12–16 × 16–25 μ. As in the previous species, no pedicels are evident. The spores, however, are apparently borne singly. By careful search a few hyphoid paraphyses can also be found. A thin hyphal layer similar to that noted in the previous species can be demonstrated beneath the overarching epidermis. The teliospores are like those in *A. lenticularis*. They measure 10–16 × 10–26 μ and form chains 18–70 μ long which adhere laterally to form compact sori. Otherwise the species is as described by Arthur and Mains. (1919). This rust has been reported on *Tripsacum latifolium* Hitch. and *T. lanccolatum* Rupr. from Mexico, Guatemala, Nicaragua, and Salvador.

Angiopsora phakopsoroides (Arth. & Mains) comb. nov.

Puccinia phakopsoroides Arth. & Mains, Bull. Torrey Club. **46**: 412. 1919.
Dicaeoma phakopsoroides Arth. & Fromme, N. Am. Flora **7**: 295. 1920.

As previously described (**5**), the teliospores were considered to be multicellular. Instead of this they appear to be unicellular, cuboid, 8–14 × 10–16 μ, catenulate in chains 20–40 μ long. The appearance of a colorless layer, described as continuous around the 2- to 3-spored chains, is probably due to the compression and adherence produced by the pressure of the compact telium. No

pedicels have been distinguished. The uredinia are bordered by abundant, peripheral, incurved paraphyses. They are also covered over, except for an irregular slit, by the overarching epidermis. The urediniospores are apparently borne singly. No pedicels could be distinguished in the herbarium specimens studied. This rust has been reported on *Olyra latifolia* L. from Cuba, Puerto Rico, and Ecuador.

Angiopsora compressa (Arth. & Holw.) comb. nov.

Puccinia compressa Arth. & Holw.; Arth. Proc. Am. Phil. Soc. **64**: 157. 1925. (Not *Puccinia compressa* Diet. Ann. Myc. **5**: 245. 1907.)

Arthur in his description of this species likens it to *Puccinia phakopsoroides* and similarly describes the vertical rows of spores as two-celled teliospores, noting however that each cell was "rounded off at the ends as if it were an independent spore." He also comments on the lack of pedicels and the lateral adherence of the rows. As in the previous species the teliospores are here interpreted as one-celled, 12–14 × 20–26 μ, in rows of 1–3, usually 2, 40–50 μ long. The uredinia are bordered by incurved paraphyses as described by Arthur. Apparently there is also a thin hyphal layer under the over-arching epidermis as in *A. lenticularis*. This rust was described on *Paspalum elongatum* Griseb. from Bolivia.

Without more information in regard to the development of these species it is difficult to place this genus in its proper relationship. The telia have both of the main distinctive characters which have been used to separate the Melampsoraceae from the Pucciniaceae, *i.e.* lack of pedicels and lateral adherence of the teliospores into compact crusts. However, in the Melampsoraceae very little information is available concerning the development in those species having catenulate teliospores. In genera with long chains such as *Cronartium* apparently the chains elongate by the successive divisions of the basal cell. Probably this also occurs in the genus *Cerotelium* which with its shorter chains of spores more nearly resembles *Angiopsora*. It seems somewhat doubtful whether *Cerotelium* with its colorless thin-walled teliospores in

chains, which are somewhat loosely held together laterally, is directly related to *Angiopsora* with its dark colored teliospores and compact sori.

The very short chains of teliospores of *Angiopsora* suggest that the development may have taken place by the successive divisions of the uppermost cell, the cell cut off from the basal cell dividing and the upper cell of the two produced again dividing to form the chain. It is possible that the basal cell sends out side buds which repeat the same process, although the rather uniform palisade arrangement of the spore chains indicates that this is doubtful. This type of development is very similar to that which takes place in the formation of teliospores of *Puccinia* except that in *Angiopsora* the resulting cells are more loosely held together in the chain, and are more firmly adherent laterally and are apparently without a pedicel. In *Angiopsora* all the cells produced apparently develop into spores. This, however, cannot be determined with certainty without a careful study of fresh material. If the supposition suggested here is correct *Angiopsora* would show a distinct tendency in the development of its telia toward *Puccinia*. If it should happen that the basal cell of the spore-chain should remain undeveloped and inconspicuous, in other words forming a poorly differentiated pedicel-cell, the genus would be placed much nearer to *Puccinia*. The fact that it is the only genus besides *Puccinia* and *Uromyces* occurring on grasses would lend some weight to this hypothesis.

This, however, would not necessarily interfere with a close relationship with *Bubakia* and probably *Phakopsora*. They would stand in a relationship to *Angiopsora* similar to that between *Uromyces* and *Puccinia*. In *Bubakia* and *Phakopsora* the cell cut off from the basal cell does not continue to divide, and the developing younger spores, possibly from lateral buds, force the older upward, and the adherence of the spores results in a somewhat similar appearing lenticular telium.

Schroeteriaster might be considered a link between *Phakopsora* and *Bubakia* on the one hand and *Uromyces* on the other. However, there are several objections to this, the principal one being the flat, open uredinium with well developed pedicels for the urediniospores. The differentiated, although fragile, pedicels of

the teliospores place it much closer to *Uromyces* than to *Bubakia*. Rather it would appear that *Schroeteriaster* is an offshoot from *Uromyces* in which a pronounced lateral adherence of the teliospores has developed resulting in a crust.

While *Angiopsora* shows a certain tendency in the direction of *Puccinia*, the uredinia would indicate that the relationship is probably not as close as that to *Bubakia*. The bullate, long-covered uredinia with bordering paraphyses, and possibly peridia, and sessile urediniospores give additional evidence of very close relationship to *Bubakia* and *Phakopsora*. It is possible that inconspicuous pedicellate cells may be formed. But this also is a situation which more commonly occurs in the Melampsoraceae than in the Pucciniaceae. It therefore seems best from the evidence available at present to place the genus *Angiopsora* in association with *Bubakia* and *Phakopsora* in the Melampsoraceae, recognizing that it shows a certain tendency of development toward *Puccinia* in the Pucciniaceae.

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EXPLANATION OF PLATES

PLATE 17

A, Two leaves of *Lasiacis ruscifolia*, Reliq. Holw. 95 (type specimen), showing telia of *Angiopsora lenticularis*, aggregated in blackish groups; *B*, Section through a telium of *Angiopsora lenticularis* showing catenulate arrangement of teliospores in the subepidermal crusts.

PLATE 18

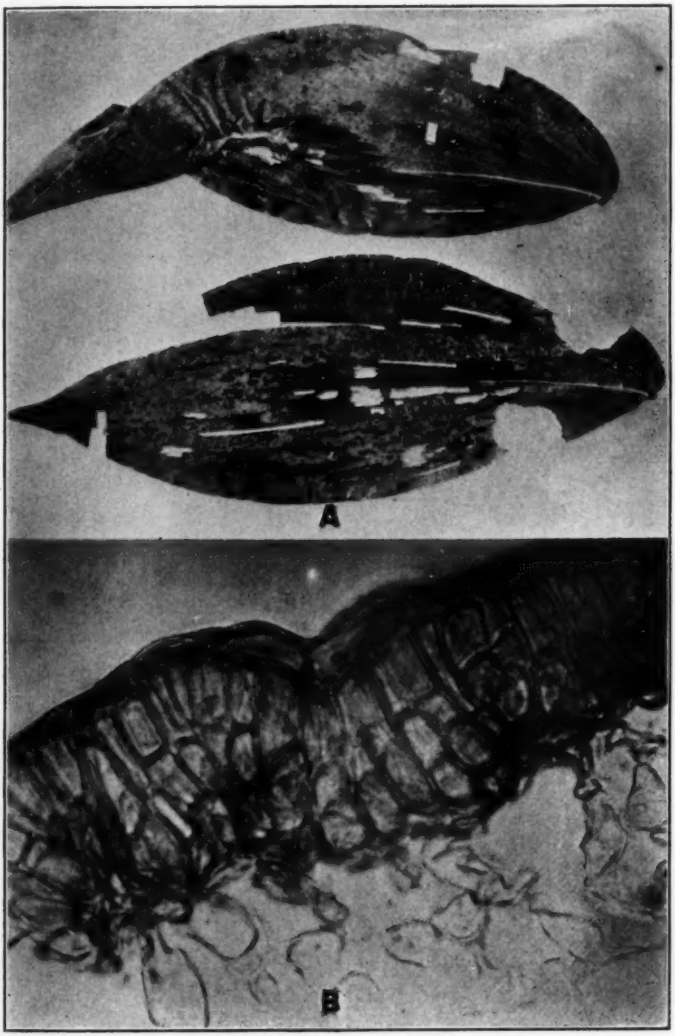
A, Section through a uredinium of *Angiopsora lenticularis* showing the overarching epidermis. There is some evidence of a thin hyphoid layer beneath the epidermis; *B*, A telium of *Angiopsora lenticularis* crushed out under a coverglass, showing the separation into one-celled teliospores.

PLATE 19

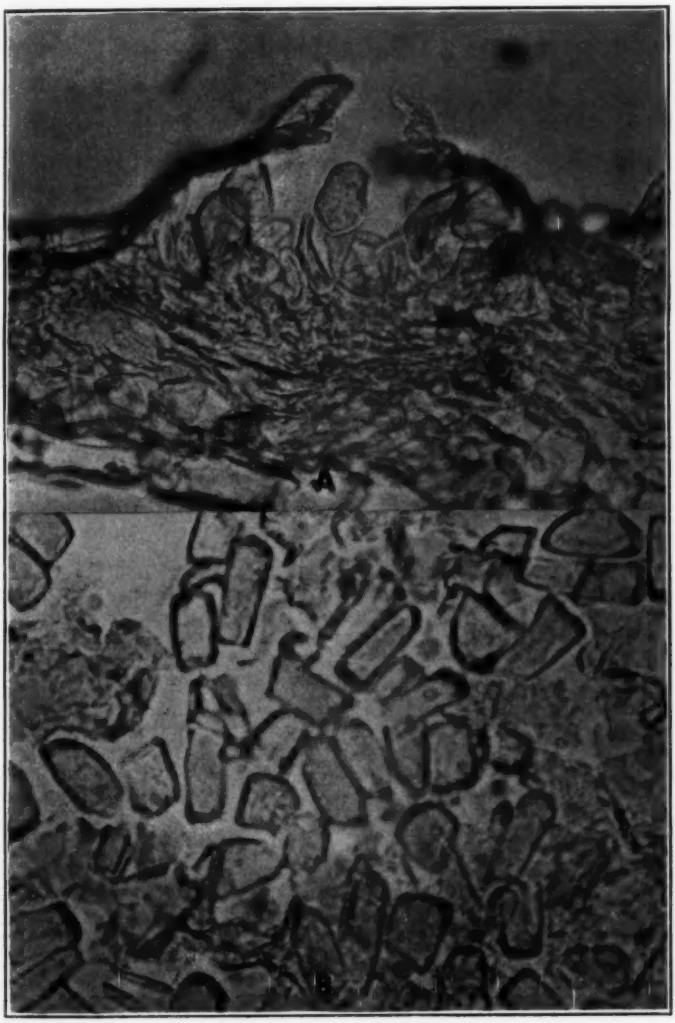
A, Section through a telium of *Angiopsora phakopsoroides* showing the arrangement of the catenulate teliospores in a subepidermal, compact layer; *B*, Section through a telium of *Angiopsora pallescens* showing a similar arrangement.

PLATE 20

A, Section through a telium of *Angiopsora compressa* showing the compact arrangement of the two-spored chains. Part of the epidermis was torn away in sectioning; *B*, Section through a uredinium of *Angiopsora compressa* showing the colorless, incurved paraphyses at the margin of the sorus.



ANGIOPSORA LENTICULARIS



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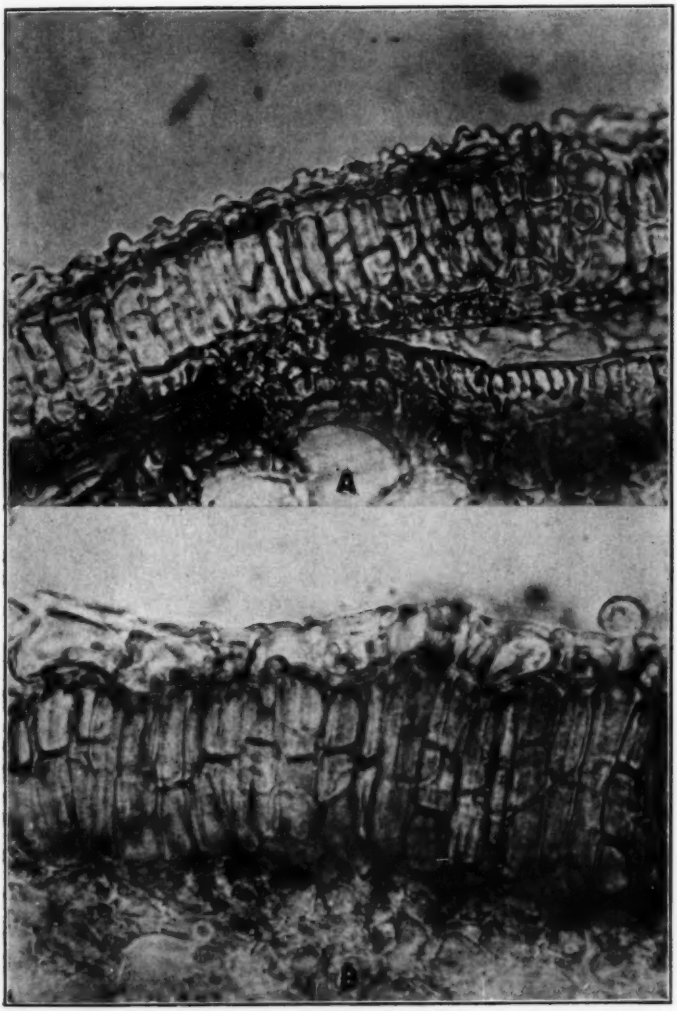
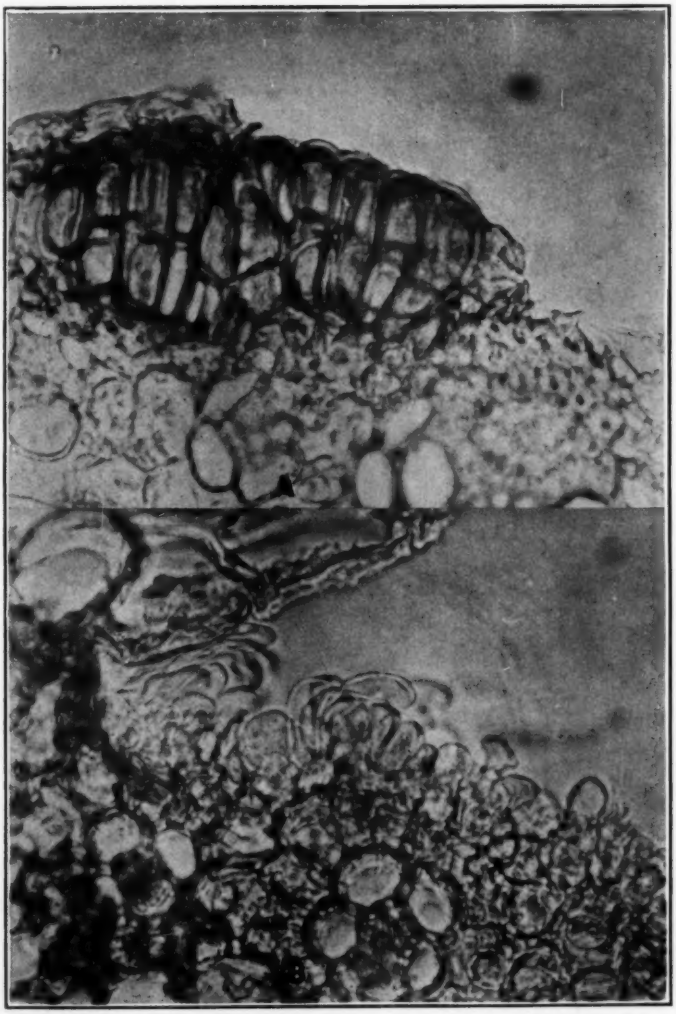


ANGIOPSORA PHAKOPSOROIDES
ANGIOPSORA PALLESCENS



ANGIOPSORA COMPRESSA

MYCOTYPHA MICROSPORA ISOLATED FROM CHAENOMELES LEGENARIA

W. F. Cherry

Aline Fenner Kempton described and illustrated a new genus of Mucoraceae (*Mycotypha microspora*) in Mycologia **24**: 187–198. 1932. She found this organism growing in mixed cultures from the isolation of a pathogen of an orange.

In an effort to isolate a fungus causing a spotting of the fruits of *Chaenomeles legenaria* (Japanese Flowering Quince) the writer discovered *Mycotypha microspora* growing in mixed cultures from the attempted isolation. The fruits from which the isolation was obtained were grown near Lafayette, Indiana. Potato-dextrose agar was used as a culture medium from which all measurements and description of the fungus were made.

The vegetative hyphae of the fungus are much branched containing a dense granular protoplasm and many vacuoles. There is a lack of uniformity in the diameter of the mycelium especially near the attachment of the secondary branches.

The cat-tail like fructifications at first are white with a pinkish tinge which becomes darker as they mature, gradually changing to a dusky slate gray. Old cultures are dark brown in color. The fructifications grow compactly together and stand erect.

The capitella vary in length from 30 to 450 microns and from 16 to 28 microns in width with spores removed. The conidia drop off at maturity leaving the hollow cylindrical head exposed. The naked capitellum appears marked with many orifices but close examination shows numerous scars where the spores were attached. The conidia vary from ovoid to spherical in shape and range from hyaline to bluish green in color. In size they vary from 4 to 6 microns. Germination was noted to take place 4 to 5 hours after being sown on the potato-dextrose agar at room temperature.

Correspondence and exchange of cultures between the writer and Aline Fenner Kempton demonstrated conclusively that the

fungus isolated from the fruits of the Japanese flowering quince was identical with the one isolated from oranges.

The author wishes to acknowledge the helpful suggestions of Dr. C. L. Porter of the Biology Department of Purdue University under whose direction the work was performed.

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ORGANS OF CAPTURE IN SOME FUNGI PREYING ON NEMATODES

CHARLES DRECHSLER

In a recent paper in this journal Sherbakoff (**14**) gave an interesting account of a fungus capturing nematodes by insnaring them in ring-shaped structures, later growing into the animals and ultimately consuming them. The ring-shaped structures he interpreted as conidia, and in the absence of any genus known to produce annular spores, he erected a new genus *Anulosporium*, for which he claimed a place near *Helicomyces* Link and *Helicoon* Morgan among the mucedinous Helicosporae. As the merit of the new genus is contingent on the essential character of the annular bodies, whether they really represent or do not represent conidia, it may not be inappropriate to direct attention more particularly to two nema-capturing Hyphomycetes, the brief characterizations and rather meager synoptic illustrations of which might readily be overlooked in the several summaries (**4**, **6**, **7**) dealing with nearly a score of predacious fungi.

The two Hyphomycetes in question produce annular structures which as the figures of them (**4**, *fig. 6, B*; **7**, *fig. 16, B*) indicate are very closely similar in dimensions and in manner of attachment. If the comparison is extended to Sherbakoff's description and photomicrographs (**14**, *pl. 35, A–C, E–G, I–K, N*) of the bodies he interpreted as the conidia of his *Anulosporium nematogenum*, a similarly striking correspondence is evident. In both species the annular structures function in insnaring the nematodes without active or serious constriction, and while rather inconspicuous differences are observable in the initial development within the animals immediately following perforation of the integument, similarity is again evident both in the frequently delayed penetration, and in the somewhat lingering decline of the prey. A doomed animal, often retaining its vigor for some hours after capture, may tear the encircling loop from its slender attachment, frequently to be caught in a second loop, and sometimes following renewed

struggles and a second liberation, even in a third. Sherbakoff's photomicrographs (**14**, *pl. 35, B, J, L 3*) showing two or three annular structures encircling captured animals, testify to a parallelism in predacious habit in the fungus reported by him.

The fact that is of most direct interest here is that the two fungi under consideration produce under favorable conditions conidiophores and conidia of types long recognized. In one of the fungi the conidia are spindle-shaped with rounded ends, measure on an average approximately 47 μ in length and 8.5 μ in diameter, contain mostly 4 and less frequently 5 septa, and are borne in loose capitate arrangement in numbers usually between 3 and 7, terminally on erect conidiophores measuring mostly about 0.3 mm. in height, 3.0 μ in diameter at the base and 1.5 μ in diameter near the tip (**4**, *fig. 6, A*). The principal details of morphology are therefore in tolerable agreement with those attributed to *Dactylaria candida* (Nees) Sacc. (= *Dactylium candidum* Nees) in the general works of Saccardo (**13**, p. 195) and of Lindau (**10**, p. 416), in both of which cognizance is taken of Bonorden's (**3**, *fig. 139*) illustrations in regard to spore septation and also of Oudemans' (**12**) measurements of spore dimensions. Some misgivings concerning the possible identity of the American with the European fungus are aroused in considering the manner of attachment of the conidia, since in my fungus the loose capitate arrangement is brought about by the spores being borne on short terminal spurs, whereas the various figures of *D. candida* show no indication of such modifications at the tip of the sporophore. Yet as the figures of *D. candida* are on a scale of magnification much too small to record such modifications, if any had been present in the material used, without considerable exaggeration, anything like a rigorous interpretation of these illustrations would seem ill-advised. It is hardly necessary to mention, moreover, that the cavalier draughtmanship prevalent in the earlier days of mycology was primarily concerned with the grosser aspects rather than with the more intimate details of external form.

The occurrence of *Dactylaria candida* on the inner surface of bark separated from an old oak stump, as reported by Bonorden (**3**, p. 82), is not at variance with a presumption that it is often or even habitually predacious on nematodes in nature, as I have found

pieces of decaying bark that have been in contact with moist soil a prolific source of many nema-capturing fungi, among the most frequent of these being, indeed, the very one considered probably identical with Nees von Esenbeck's species. Oudemans' discovery on goat dung of the fungus to which he attached the same binomial, provides a circumstance perhaps even more suggestive of a predacious habit, especially as he reported in the same paper, and it may be assumed as a result of similar handling of gross cultures, the occurrence of *Arthrobotrys oligospora* Fres. also on goat dung, and the discovery of his *Monacrosporium elegans* on rabbit dung. The conidium of the latter fungus (**12**, *fig. 9*) shows such an obvious family resemblance to that of one of the species of *Dactylaria* figured earlier (**4**, *fig. 5, A*) as well as to the spores of two of the species of *Monacrosporium* (**6**, *fig. 12, A*; **7**, *fig. 17, A*), that the presumption of a similar biological relationship is difficult to avoid.

From a consideration of morphological similarities and of the character of the substratum in encouraging the multiplication of nematodes, a fair presumption can be entertained that *Monacrosporium subtile*, another fungus described by Oudemans from rabbit dung in the same paper with the species already cited, represents likewise a nema-capturing form. One (**12**, *fig. 10 a*) of the two conidia figured by Oudemans shows at least a moderate resemblance to the conidia produced by the second of the two fungi isolated by me that capture nematodes in delicate, solitary, non-constricting loops (**7**, *fig. 16, B, C*), though because of the pronounced clavate shape of the other spore (**12**, *fig. 10 b*) figured by the Dutch investigator, there would appear to be somewhat greater likelihood of the plants being congeneric rather than conspecific. For the conidia of the American fungus in question are narrowly fusoid, suggesting in shape and septation the macroconidia of various species of *Fusarium*, yet lacking the curious basal modification usual in the latter, and being formed only on discrete conidiophores (**7**, *fig. 16, A*).

As has been mentioned the non-constricting loops or rings present in the fungus provisionally identified as *Dactylaria candida* are so closely similar to those produced by the *Fusarium*-like species of *Monacrosporium* just discussed, that the two plants could not well be distinguished by these structures. Apart from

the very obvious differences in conidiophores and conidia, the former may be recognized by the production individually on delicate stalks, within the substratum, of characteristic globose cells, about 4 or 5 μ in diameter (**4**, *fig. 6, B*), the equivalent of which I have not observed so far on the mycelium of the latter in nematode-infested plate cultures. These cells manifestly correspond to the "globular bodies" described by Sherbakoff for his *Anulosporium nematogenum*, and that with such exactness that specific identity is very strongly suggested. Even if, as seems probable, similar solitary non-constricting loops and similar globose bodies will ultimately be found associated in other nema-capturing fungi—and undoubtedly more than a few of the supposed saprophytes described from excrement of various animals or from decaying plant remains, that are compiled in the "Sylloge fungorum" in such genera as *Arthrobotrys* Corda, *Trichothecium* Link, *Cephalothecium* Corda, *Dactylaria* Sacc., *Dactylella* Grove, *Dactylium* Nees and *Monacrosporium* Oud. will prove to be predacious—it seems doubtful whether a more thoroughgoing agreement will ever be brought to light.

The globose cells which Sherbakoff sets forth as representing an early stage in the development of the annular loops, can, I believe, be more appropriately interpreted as constituting in themselves completed organs of capture, independent of the loops, and designed to take smaller, or in any case, less vigorous prey. In flourishing agar plate cultures of the fungus tentatively identified as *Dactylaria candida*, annular organs can be seen in all stages of development including the earliest stages, but the resemblance of such earliest stages to the globose bodies is certainly not impressive. Again, in the *Fusarium*-like species of *Monacrosporium* similar loops are formed, though globose cells have not been seen associated with them.

The true character of such globose cells would seem revealed in the larger and more robust but otherwise apparently similar structures (**4**, *fig. 7, B*) occurring in a fungus, the solitary conidia of which, typically broadly spindle-shaped and 4-septate, and measuring 30 to 65 μ in length by 13 to 18 μ in diameter, are borne terminally on erect conidiophores approximately 0.2 mm. in height (**4**, *fig. 7, A*). As this fungus was derived frequently from pieces

of rotten wood, a rather satisfactory agreement with *Dactylella ellipsospora* described by Grove (**9**) from England in 1886, prevails with respect to source as well as to morphology of conidiophore and conidium.[1] In any case the globose bodies here are functional in the capture of nematodes in causing them to adhere by means of an adhesive substance, which then soon becomes visible as a cushion-like deposit of transparent, colorless, gelatinous material through the middle of which a narrow process is thrust forth to perforate the animal's integument (**4**, *fig. 7, C*). They correspond well in shape, dimensions and performance, to the subspherical structures described by Zopf (**16**) for his *Monosporidium repens*, which he found abundantly destructive to nematodes in rabbit dung. Either because this nema-capturing fungus of Zopf's failed to produce conidia, or probably because the opaque substratum obscured the organic connection between the conidiophores and the globose bodies, he took the latter to be conidia themselves. Since the German investigator, owing very probably to the greater limitations of the microscopes then available, failed to see the highly transparent adhesive substance by means of which the animals were held fast, his account was phrased in most cautious yet under the circumstances quite justifiably non-committal words: "Merkwurdiger Weise geht, soweit meine Beobachtungen reichen, die Infektion stets von der Conidie aus. Sie legt sich an den Wurm an, ..." None could have realized better than he that the application of a non-detachable globose body, whether conidium or other structure, to an animal as active as a nematode, could not have results very serious for the animal unless in some way the latter was prevented from discontinuing the inimical contact.

It is of historical interest that in failing to see the adhesive substance by means of which the supposed conidia of his *Monosporidium repens* held fast their prey, Zopf missed a clue which might well have led to a truer explanation of the efficacy of the anastomosing hyphal loops of *Arthrobotrys oligospora*. In many cases, to be sure, these loops come to enwrap the struggling nema-

[1] Evidently the same fungus was described later from rabbit dung in Bohemia by Bubak as *Monacrosporium leporinum* (Ann. Myc. **4**: 120–121. 1906).

tode with such evident security that the capture appears purely one of mechanical involvement. In numerous other cases, however, the animal is held very close to its oral region where in many species the forward tapering of the body is so marked that extrication would appear to ensue from even a slight backward movement. Or, again, the body of a captured nematode is in contact with the inner surface of the loop over only a small segment of its circumference, so that the animal can not properly be said to be insnared at all. Examination immediately after the moment of capture ordinarily yields no explanation as to why the violent struggles of the animal should be so ineffectual. After some time, however, a coating of colorless, transparent, mucilaginous material of manifestly strongly adhesive properties becomes visible about the areas of contact between hyphal loop and nematode, and continues to increase in thickness and to spread in extent as the struggles are maintained, until in the end it attains considerable volume.

Although on microscopic examination the anastomosing hyphal loops of *Arthrobotrys oligospora* previous to the capture of nematodes do not reveal any coating of adhesive material, the behavior of the animals in coming in contact with these structures provides excellent indirect evidence that such substance is present. The animals show no alarm or embarrassment in brushing ordinary hyphae as they make their way over the surface of agar plate cultures containing mixtures of various fungi, but on touching a hyphal loop they draw back with a suddenness and violence hardly equalled by a person touching a hot stove with his hand. Through this energetic reflex the animals escape capture, in perhaps nine cases out of ten, so that the enormous numbers that are taken and destroyed daily by the fungus in a petri dish culture yet represent only a relatively small proportion of the encounters that occur between nematodes and organs of capture. As might be expected the same reflex is evident in the behavior of nematodes in agar cultures of the various other fungi in which the apparatus of capture likewise consists in whole or in part of an anastomosing system of hyphal loops produced on the surface of the substratum, and in which colorless transparent adhesive material similarly becomes visible following its effective intervention. Among these fungi are included not only most other forms with 1-septate spores

borne in capitate or loosely capitate arrangement, which even when the arrangement is not repeated at successive nodes, would seem more correctly assignable to *Arthrobotrys* since Matruchot (**11**) and later Elliott (**8**) have shown that the mode of spore formation in *Cephalothecium roseum* Corda (= *Trichothecium roseum* Link), the type species of the genus *Cephalothecium*, is fundamentally different, but also at least one species with swollen, typically 3-septate spores assignable evidently to *Dactylaria* (**4**, *fig. 5, A*) and another with swollen, 3-septate or 4-septate spores (**6**, *fig. 12, A*) which appears eligible for inclusion either in *Monacrosporium* or in *Dactylella*.

As in the fungus last referred to the superficial hyphal loops arise by the development of bridging connections between rather regularly spaced, short, bristling, mostly 2-celled processes (**6**, *fig. 12, B*), which are adhesive more especially on the distal cell, the performance of organs of capture corresponding substantially to the type illustrated by Zopf for his *Monosporidium repens* and to the type exemplified in *Arthrobotrys oligospora* can here be observed side by side. It now becomes apparent that the stubby processes are effective mainly in the capture of the younger, smaller animals, whereas the closed loops by restricting the movements of the prey, and especially by engaging it over a much more extensive adhesive surface, are adapted to hold even the fully grown vigorous adults. It was no mere coincidence therefore that Zopf found his *Monosporidium repens* destructive to "eine auffallend kleine und schmale . . . Anguillulide." Similarly in agar plate cultures captures on the adhesive knob-cells of the probably identical fungus which from the morphology of its conidia would seem the same as *Dactylella ellipsospora*, were found restricted to the smaller individuals of the species of *Rhabditis*, *Cephalobus* and *Diplogaster* present. The considerably smaller structures represented in the globose cells produced by the fungus provisionally identified as *Dactylaria candida* could therefore hardly be expected to retain any but the smallest larvae, and that perhaps only in the absence locally of firm material providing leverage for the struggling prey. Their usual inefficiency as organs of capture in agar culture media consequently need not imply any lack of effectiveness

in the various materials of far different texture which constitute the field of predacious activity in nature.

Whether adhesive material is present on the solitary non-constricting loops which Sherbakoff interpreted as conidia, remains somewhat uncertain. None has been observed, but as these organs in both of the species known to produce them are formed within the agar instead of on the surface, the increased optical difficulties might possibly account for this failure. Yet altogether apart from considerations based on direct visual evidence, the performance of these organs is not such as to indicate any necessity for prolonged participation by adhesive material. In all cases of capture they soon fit very snugly around the insnared prey, generally, indeed, becoming jammed so tightly on the tapering body of the struggling animal that the integument is noticeably indented at all points along the circumference of contact (**7**, *fig. 16, C*).

The same optical difficulties intervene in the examination of the constricting loops formed in some predacious representatives of the genera *Trichothecium* (**4**, *fig. 10*), *Arthrobotrys* (**6**, *fig. 13*), *Dactylaria* (**6**, *fig. 14*) and *Monacrosporium* (**7**, *fig. 17*). In none of these representatives has adhesive material been observed, and obviously such substance could here be of no possible use except perhaps for a brief period immediately following capture. Once the swelling of the three component cells is under way, the constricting loop reveals itself as a powerful compressing mechanism as remarkable in adaptation to its special function as it is conspicuous among devices employed by carnivorous plants for the impression of unrelenting malevolence it conveys.

In any case, however, the utilization of adhesive material on the organs of many of the nema-capturing Hyphomycetes provides an important parallelism between this group of predacious forms and the various predacious Phycomycetes that have become known, including the two nema-capturing species figured earlier (**4**, *fig. 8;* **6**, *fig. 15*). In these two fungi the adhesive substance is apparently of a different composition from that common to the several Hyphomycetes, as it very soon assumes a deep golden yellow color which makes it very readily visible under the microscope. Its adhesiveness too would seem to be markedly stronger, as in the form bearing large obovoid conidia on tall erect conidiophores (**4**, *fig. 8, A*).

nearly fully grown nematodes are held securely. A bulbous expansion broadly fused to the animal here usually puts into appearance (**4**, *fig. 8, C*), but as its development apparently occurs after capture of the nematode and preceding perforation of the integument, it seems probable that its function may be more directly related to the latter event than to the former. Both in this fungus and in the nema-capturing fungus which appears referable to the genus *Pythium* Pringsh. (**6**, *fig. 15*) external mycelial modification at the time and place of capture is absent or so inconsiderable that one can hardly speak of special organs. The sigillate outline so characteristic of the cushion of adhesive material attaching the prey to the *Pythium* filament is, of course, not to be interpreted as a result of morphological differentiation. It merely indicates rather that the fashioning of the cushion is closely comparable to the fashioning of a wax seal which it simulates, the struggling animal evidently exerting on the mass of plastic adhesive material a pressure analogous to the pressure of a stamp on heated wax. Yellow adhesive material of similar appearance and consistency is effective in the capture of amoebae by a series of unusually delicate Phycomycetes, which as has been set forth, bear distinctive aerial conidia and small intramatrical sexual organs (**5**, *figs. 2–5*).

Possibly the general similarity in manner of taking prey furnishes a slight indication of taxonomic affinity between the delicate amoeba-capturing Phycomycetes and the much sturdier nema-capturing form with large obovoid conidia. That the latter fungus is not a lone representative of its type has recently become evident through the discovery of several undoubtedly congeneric nema-capturing forms, which more frequently come to bear a number of conidia on a conidiophore, following the repeatedly continued growth of the supporting stalk below each successive terminally formed reproductive body. Whether the large non-septate aerial conidia of these forms can be homologized with the submerse and even larger gemmae which Arnaudow (**2**) described as being produced by the aquatic rotifer-capturing *Zoophagus insidians* Somm. remains uncertain for the present. If analogy is not misleading, the diversity in apparatus of capture found among the fairly closely interrelated Hyphomycetes predacious on nematodes would in-

dicate that the production of the somewhat specialized organs of capture in the short adhesive branches described by Sommerstorff (**15**) and by Arnaudow (**1**) in the original accounts of *Z. insidians* and the similarly aquatic, rotifer-capturing *Sommerstorffia spinosa* Arn. respectively, need not preclude relationship to forms without such predacious modifications.

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THE STRUCTURE AND DEVELOPMENT OF A NEW AQUATIC PHYCOMYCETE[1]

ARTHUR G. KEVORKIAN

(WITH 11 TEXT FIGURES)

Among the aquatic Phycomycetes the genus *Araiospora* of the family Leptomitaceae was first established by Thaxter in 1896 upon the single species *A. pulchra*. The genus is readily distinguished by the presence of two types of sporangia, one subcylindric with thin, smooth wall, the other obpyriform with thick, spinose wall, and by the formation within the oögonium of a periplasmic layer of hexagonal appearing cells surrounding the central oöspore. To this newly erected genus Thaxter at the same time (**1896**) transferred Cornu's *Rhipidium spinosum* (**1872**) because of its spinose thick-walled "secondary" sporangia, calling this new combination *A. spinosa*. It remained for von Minden (**1915, 1916**), however, to add to our knowledge of this scantily described species, for from material collected and studied in Germany he described in detail the developmental stages not only of the sporangia but also of the sexual organs hitherto unknown. Since the two foregoing species were both characteristic of temperate regions, Linder's (**1926**) description of a new species from British Guiana is of interest, for it is the first instance in which a member of the genus *Araiospora*, or indeed a representative of the entire family, has ever been reported from the tropics. This species, *A. coronata*, is unique in that the 4 to 6 spines about the apical exit papilla of the "secondary" sporangia are 7.9 μ in length, whereas in *A. spinosa* the spines are more numerous and much longer (60–70 μ). Although the sexual organs were not found in Linder's species, there was ample basis for his establishing it as new since in addition to the distinctive number and arrangement of the spines the sizes of the various organs differed from those of the already established species (see TABLE 1).

[1] Contribution from the Cryptogamic Laboratories of Harvard University No. 125.

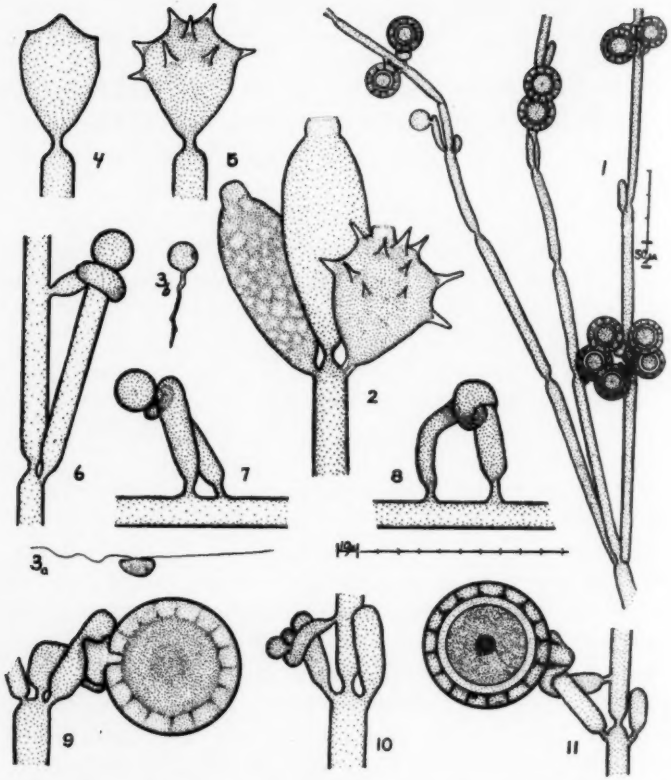

Fig. 1–11. All drawings were made from material mounted in lacto-phenol and cotton blue and were drawn with the aid of a camera lucida with 10 × ocular and 4 mm. objective, with the exception of figure 1, which was drawn with 10 × ocular and 16 mm. objective. Each division of the scale accompanying figure 1 equals 50 μ; of the other scale, which applies to the remaining figures, each division equals 10 μ. 1, Portion of a plant showing the arrangement and grouping of the sexual organs. × 65; 2, A terminal portion of a sporangiophore showing the smooth and spinose types of sporangia. The spinose and one of the smooth sporangia have already discharged their spores. × 350; 3a, A typical laterally biciliate zoöspore, 3b, Germination of zoöspore by means of a germ tube which later becomes a much branched rhizoidal system. × 350; 4–5, Stages in the development of the spines of the spinose type of sporangium. × 350; 6, 7, 8, and 10, Early stages in the development of the sexual organs, figures 6 and 10 showing the origin of the antheridium and oögonium from two adjoining

Since this genus so far has comprised but these three species, of which only two are known to show sexual reproduction, the finding of an additional sexually reproductive species with antheridia characteristically and distinctively twined about the base of the oögonia seems to justify bringing it to the attention of mycologists in the present note. This organism, which for reasons appearing later in this paper will be called *Araiospora streptandra*, was found growing saprophytically on submerged twigs of *Prunus* and *Salix* in ponds and ditches around Rhode Island State College, Kingston, R. I., and near Cambridge, Massachusetts, during the months of April and May in 1931, 1932, and 1933. Gross cultures were perpetuated by transferring selected portions of twigs infected with the desired fungus but relatively free from other organisms, to cooled mason jars partially filled with sterile distilled water, adding twigs of *Acer* and *Prunus* from time to time to support new growth, and changing the water frequently to offset the accumulation of bacteria and other decomposing agents. It would, of course, have been desirable to grow this fungus in pure culture on artificial media as von Minden (**1916**) successfully cultured *Araiospora spinosa* and *Rhipidium europaeum*, but unfortunately the writer, like others (Kanouse, **1927**, p. 290), was unsuccessful in attempts even though he followed von Minden's methods most carefully and also tried numerous variations of it. Yet even though pure cultures were not obtained, the gross cultures mentioned above allowed the fungus to complete its life cycle apparently normally under conditions approximating those in nature.

Under these conditions the fungus was studied in its various stages and found to show the following structure and development.

DEVELOPMENT OF THE FUNGUS

Thallus. The zoöspore of *Araiospora* upon germination gives rise to a slender germ-tube (FIG. 3b) which in turn branches into

segments of the mycelium, whereas figures 7 and 8 show the origin of the sexual organs from the same segment. × 350; 9, Later stage in the development of the sexual organs, showing irregularly outlined antheridium with fertilization tube, and oögonium differentiating into peri- and oöplasm. × 350; 11, More advanced stage of the oögonium showing, in optical section, the peripheral layer of hexagonal-appearing cells surrounding the thick-walled central oöspore. × 350.

a definite rhizoidal system extending into the tissues of the substratum. In the meantime the zoöspore body elongates and develops into a greatly enlarged, sub-cylindrical, basal segment in a fashion comparable to that described in detail by Linder (**1926**) for *A. coronata*. From the sub-conical apex of this basal segment, are borne many repeatedly and umbellately branched filaments, which are constricted at regular intervals, each successive member becoming more elongate and slender than its predecessor, the plant thus presenting an arbusculate appearance (FIG. 1), typical of the higher Leptomitaceae and the Blastocladiaceae.

Sporangia. The two types of sporangia found in the other species of the genus *Araiospora* are present in this species also. Both of these, the smooth, thin-walled, sub-cylindrical to broadly clavate type (FIG. 2), and those which are thick-walled, broadly oval, pyriform, and spiny (FIG. 2, 4, 5), are borne in whorls of 2 to 6 at the distal ends of the segments.

The thin-walled smooth sporangium is very similar to that of the genus *Sapromyces,* but the subsequent formation of spinose sporangia separates the two rather closely related genera. These sporangia appear as small, knob-like bodies separated from the rest of the mycelium by constrictions which are elongated, heavy-walled, collar-like modifications of the hyphal walls (FIG. 2). The protoplasm which flows in from adjoining segments passes through the narrowed openings and causes the sporangium to elongate, until finally the contents of the large (79–111 $\mu \times$ 29–49 μ), sub-cylindrical body begins to differentiate into zoöspores, whereupon the lumen of the constriction is obliterated by the additional centripetal thickening of the wall at the constriction.

Save for the thicker walls, the spinose sporangia (60–78 $\mu \times$ 46–63 μ) resemble the smooth type in their early stages. A little later in their development, however, small protuberances begin to appear at the apical portion of the sporangial wall (FIG. 4) and develop in basipetal succession (FIG. 5). When mature, the 10 to 15 elongate conical spines (15 to 30 μ in length) are scattered over the surface of the sporangium in a regular manner, as in *A. pulchra* Thaxter.

Both types of sporangia show great similarity, not only in the early stages of development described above, but also in the subse-

quent formation of zoöspores. The scattered median vacuoles increase in size and coalesce until they occupy a large central area. A decided swelling of the sporangium follows, accompanied by changes in texture of the protoplasmic content, and the first signs of zoöspore differentiation become apparent. The zoöspore initials next make their appearance as densely granular, somewhat angular masses filling the entire sporangium, and when completely differentiated are discharged through an apical modification of the sporangium wall, the papilla of dehiscence. Upon emergence the zoöspores linger about the mouth of the sporangium for a few seconds, until they have assumed their typical, somewhat kidney-shaped, laterally biciliate form (FIG. 3*a*), and then with a few twitching movements orient their cilia and swim away. Their activity is monoplanetic, for after a period of swarming about they lose their cilia, come to rest, round up, and later germinate by giving rise first to a rhizoidal system and subsequently to the elongated enlarged basal cell as already described.

Sexual organs. The sexual organs, which develop some time after the sporangia and which in the material collected were usually found more abundantly in the spring, consist of large spherical oöspores surrounded by a layer of peripheral cells which in surface view are hexagonal and borne on short lateral branches, either singly or in clusters of two to four (FIG. 1, 11) near the distal ends of the hyphal segments; and of antheridia, which are irregular in shape, borne on similar branches near the oögonia, twisted about the constriction separating the oögonium from the stalk cell (FIG. 10).

Antheridia. The antheridia develop as short lateral branches arising usually near the oögonial initials (FIG. 7, 8), less commonly at some distance (FIG. 6), and twining around the oögonial stalk as in *Pythium mastophorum* Drechsler (**1930**) and other related species. When mature, the terminal portion of the antheridium, swollen and somewhat irregularly lobed, is attached to the base of the oögonium close to its juncture with the stalk. From the mature antheridium a slender fertilization tube penetrates the oögonial wall without indenting it (FIG. 9), and extends some distance into the oösphere, as described by Thaxter (**1896**) in the case of *A. pulchra*. This is contrary to the description of King

(1903), who, on the basis of cytological evidence in that species, interpreted this fertilization tube as formed by the periplasm of the oögonium just previous to fertilization. Cytological observations upon this new *Araiospora,* to be undertaken later, will, it is hoped, ultimately settle this disputed point. A large portion of the antheridial protoplasm is next discharged into the oösphere by the rupturing of the tip of the fertilization tube, leaving the antheridium vacuolate, or even empty.

Oögonia. The oögonia first appear as small, knob-like projections (FIG. 6, 7) borne singly or in clusters on short lateral branches from which they are separated by constrictions. Early in the development of the oögonia the antheridia become applied to the oögonial walls. As the oögonium matures, the finely granular, homogeneous texture of its content gradually becomes coarsely and more densely granular in the central portion, while the periphery remains unchanged, thus differentiating a dense central oöplasm surrounded by a peripheral area of finely granular periplasm. At maturity the spherical oögonium, 52 to 68 μ in diameter, and with hyaline to yellowish wall 3 to 6 μ thick, contains a peripheral zone of several more or less hexagonal-appearing peripheral cells (8 to 12 μ in diameter) of periplasmic origin, surrounding the single central oöspore of oöplasmic origin, 39 to 46 μ in diameter, with a dense content including a single central oil mass, and with a heavy wall 8 to 10 μ thick.

RELATIONSHIP AND IDENTITY

Araiospora streptandra, although rather closely related to *A. pulchra,* is readily distinguishable because its peculiarly twisted, usually unbranched, irregular antheridium is borne as a short lateral branch near the distal end of any given segment and applied at the base of the laterally borne oögonium, whereas in *A. pulchra* the antheridial branches are terminal, usually recurved, and applied, without twisting or turning, to the bases of terminally borne oögonia. Moreover, the androgynous antheridium and the numerous scattered spines of this new species, in contrast to the diclinous antheridium and apically located spines of the "secondary" sporangium of *A. spinosa,* readily separate *A. streptandra* from this latter species.

In addition to these outstanding qualitative characters which distinguish this new form, there are certain quantitative differences in the size of important organs, as is shown in the following comparative table.

TABLE 1

Organism	Smooth Sporangia	Spiny Sporangia	Spines	Oöspores	Oögonia
Araiospora pulchra	120–175 × 30–35μ	48–70 × 45–60μ	10–35μ	35–45μ	50–60μ
A. spinosa	90–150 × 45–60μ	100–150 × 40–80μ	60–70μ	Measurements not given	
A. coronata	63–85 × 11.5–16.2μ	68–130 × 12–26μ	7–9μ	Not known	
A. streptandra	79–111 × 29–49μ	60–78 × 46–63μ	15–30μ	39–46μ Av. 44–46μ	52–68μ

It is obvious from the characteristic arrangement of the sexual organs, together with various dimensional differences presented in table 1, that this is a species hitherto undescribed. Its diagnosis therefore is given as follows:

DESCRIPTION

Araiospora streptandra sp. nov. Large sub-cylindrical basal cell with many branches arising from the sub-conical apex. Branches separated by constrictions and repeatedly and umbellately branched, each successive segment becoming more elongate and slender than its predecessor. Sporangia borne singly or in whorls of two to six, of two types (1) sub-cylindric or broadly clavate and smooth, 79–111 × 29–49 μ, (2) oval or pyriform and spiny, 60–78 × 46–63 μ. Spines numerous, 15 to 30 μ in length, elongate conical in shape. Antheridia borne singly on short, stout lateral branches, usually originating near the distal ends of the segments, twisted about the base of the oögonia, irregular in outline. Oögonia spherical, 52–68 μ (Av. 60–64 μ), arising similarly to and usually near the antheridia. Oöspore spherical, 39 to 46 μ (Av. 44 to 46 μ), surrounded by a single layer of hexagonal-appearing

peripheral cells derived from the periplasm. Germination of the oöspore not observed.

On submerged twigs of *Prunus* and *Salix*, in the vicinity of Rhode Island State College, Kingston, Rhode Island, and of Cambridge, Massachusetts.

Type material deposited in the Farlow Herbarium.

Cellula fundamentale magna, sub-cylindrata, ramis densis ex apice sub conico orientibus. Ramis identidem constrictis et racemose diffusis quorum segmenta longiora angustioraque gradatim fiunt. Duorum exemplorum altero sporangio subcylindrico et leve (79–111 × 29–49 μ) in apice tumescente; altero spinis numerosis (15 to 30 μ) aut ovato aut forma piro simile (60–78 × 46–63 μ) singulo aut numero ad sex in orbem consistentes ex extremis segmentis aut ex extremo segmento singulo. Antheridiis forma inconstante singulariter orientibus ex lateralibus ramis brevibus et robustis plerumque prope extrema segmenta ulteriora quae circum basim oogoniarum se torquent. Oogoniis globosis, 52–68 μ (av. 60–64 μ), in modo antheridiorum orientibus quibus proxima sunt. Oosporis globosis strato cellularum sexangularum ex periplasma deductorum circumdatis. Germinatio oosporarum non observata.

Hab. In ramulis *Pruni* et *Salicis* submersis ad Rhode Island State College, Kingston, Rhode Island et Cambridge, Massachusetts.

In conclusion the writer wishes to acknowledge his indebtedness to Professor W. H. Weston, Jr., for his helpful criticism and constant interest, and to Dr. David H. Linder for advice and for material of *Araiospora coronata*.

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NEW GENERA AND SPECIES OF LICHENS FROM THE HERBARIUM OF BRUCE FINK. II.[1]

JOYCE HEDRICK[2]

1. **Synechoblastus wyomingensis** Fink, sp. nov.

Transformans hospitalem algam in corpus irregulare, ascendens multilobatum, leve, obscure olivaceum et nigrescens, lobis numerosis, brevibus, integris aut sinuosis, infra levibus et pallidibus; apothecia parva, 0.75–1.4 mm. lata, sessilia in marginibus loborum, disco plano vel leviter convexo, rufescenti-fusco et obscuriore, excipulo algoideo prominenti, integro, concolore thallo; sporae 4 rare 8, decolores, ellipsoideo-acutae et interdum extentae in appendicem 3–5 μ longam, 3-septatae, 22–32 $\times$ 6.5–9.5 μ.

Transforming the algal host into a small, thin, irregular, ascending, much lobed, smooth, dark olive green and blackening body, the lobes numerous, short, entire or sinuose; smooth and lighter colored below; apothecia small, 0.75–1.4 mm. across, sessile along the margins of the lobes, the disk flat to slightly convex, reddish brown and darker, the algoid exciple prominent, entire, colored like the thallus; hypothecium hyaline; hymenium hyaline below and brownish above; paraphyses thick, septate, hyaline below and brownish toward the rarely branched apices; asci clavate; spores 4—rarely 8, hyaline, ellipsoid-pointed and occasionally extended into an appendage 3–5 μ long, 3-septate, 22–32 $\times$ 6.5–9.5 μ.

The algal host is *Nostoc*.

On limestone cliff east of Laramie, Wyoming, collected by Edwin B. Payson, No. *4233*, November 16, 1924 (type).

Similar to *S. laciniatus* (Nyl.) Fink, but the lobed thalloid body somewhat smaller and the algoid exciple more prominent. The spores larger than in *S. laciniatus*, and the pointed end sometimes extending into an appendage which would separate it from all other species known from the United States.

2. **Collema fayettense** Fink, sp. nov.

Transformans hospitalem algam in corpus parvum et tenue vel crassiusculum, irregulare lobatum, viridescens vel viridi-fuscum, lobis levibus

[1] No. 1 of this series appeared in Mycologia **25**: 303–316. 1933.

[2] Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 434.

vel leviter rugosis, demum plus minusve imbricatis, adscendentibus ad marginem crenatis; infra pallidioribus et saepe minute rugosis, hyphis saepe protrudentibus in minutis areis pleremque marginalibus; apothecia minuta vel parva, 0.1–0.3 mm. lata, numerosa, immersa, disco concavo vel fere plano, fusco, excipulo algoideo leviter crasso et prominenti; sporae 8, decolores, oblongae vel ellipsoideo-acutae, 3–4 transverse septatae et 1 longitudinal septatae, 18–22 × 9–11 μ, inconditae.

Transforming the algal host into a small, thin to somewhat thick, irregularly lobed, greenish to greenish brown body, the lobes smooth to somewhat wrinkled, becoming more or less imbricated, with crenate, ascending margins; lighter below and often minutely wrinkled, the hyphae often protruding in minute whitish areas commonly along the margin; apothecia minute to small, 0.1–0.3 mm. across, numerous, immersed, the disk concave to almost flat, brown, the algoid exciple rather thick and prominent; hypothecium hyaline or tinged brownish; hymenium hyaline; paraphyses more or less coherent and indistinct; asci long-clavate; spores 8, hyaline, oblong to ellipsoid-pointed, 3–4-septate transversely and 1-septate longitudinally, 18–22 × 9–11 μ, irregularly arranged.

The algal host is *Nostoc*.

On exposed limestone near Big Rock, Fayette, Iowa, collected by Bruce Fink in 1896 (type), Fink Herb. No. *15, 482*.

Similar to *C. plicatile* Ach., but the margins of the lobes are not plicate, the apothecia are much smaller and the spores are shorter.

3. **Collema pustulatum heterosporum** Fink, subsp. nov.

Sporae oblongo-ellipsoideae, una extremitate subplanae, 3–5 transverse septatae et 1–3 longitudinale septatae, aut rare sphaeroideae et 3–5 septatae transverse et longitudinale, 25–28 × 13–14 μ, inconditae aut rare uniseriatae.

Spores oblong-ellipsoid with one end slightly flattened, 3–5-septate transversely and 1–3-septate longitudinally, or rarely sphaeroidal and 3–5-septate transversely and longitudinally, 25–28 × 13–14 μ, irregularly or rarely uniseriately arranged.

On rocks in Florida, collected by Britton and Britton (type), Fink Herb. No. *15, 483*.

4. **Leptogium perminutum** Fink, sp. nov.

Transformans hospitalem algam in corpus parvum, tenue, rugosum et inaequale, tenaciter adnatum, nigrum, plus minusve intectum ramulis minutis et coralloideis, cortice plectenchymatico; apothecia minuta, 0.1–0.3 mm. lata, adnata vel sessilia, rotundata, numerosa, dispersa aut aggregata, disco concavo vel plano, fuscescento vel rufescenti-fusco vel fuscescenti-nigro, madido

lucide rufescenti-fusco, excipulo algoideo tenui vel crassiusculo, levi vel rare leviter confragoso aut crenato; sporae 8, decolores, ellipsoideae vel acuto-ellipsoideae, 5 transverse septatae et 1–3 longitudinale septatae, loculis fere cubicis, 18–25 × 8–10 μ, inconditae.

Transforming the algal host into a small, thin, wrinkled and irregular, closely adnate, black, crust-like body, more or less covered with minute coralloid branchlets, the cortex plectenchymatous; apothecia minute, 0.1–0.3 mm. across, adnate to sessile, round, numerous, scattered or clustered, the disk concave to flat, brownish to reddish brown or brownish black, bright reddish brown when moistened, the algoid exciple thin to moderately thick, smooth to rarely somewhat rough or wavy; hypothecium hyaline; hymenium hyaline to yellowish; paraphyses unbranched, distinct and parallel or becoming conglutinate; asci clavate; spores 8, hyaline, ellipsoid to pointed-ellipsoid, 5-septate transversely and 1–2-septate longitudinally, the cells almost cubical, 18–25 × 8–10 μ, irregularly arranged.

The algal host is *Nostoc*, found in short chains.

On old wood in woods near Oxford, Ohio, collected by Bruce Fink, May 1927 (type).

The thalloid body similar to that of *L. rhyparodes* Nyl. and *L. schraderi* (Bernh.) Nyl., but perhaps more like that of *L. tenuissumum* (Dicks.) Fries, but less covered with apothecia; the apothecia smaller and the spores much smaller.

5. **Lecidea congesta** Fink, sp. nov.

Thallus parvis, rotundatis vel difformis saepe asper dispersis verrucis, virescenti-glaucis vel sordide fuscis vel obscuris; apothecia parva vel mediocria, 0.4–1.8 mm. lata, adnata, disco convexo, pallido vel obscuro fusco, excipulo tenui, cincto velo thalli tenuissimo, solum conspicuo ad margines basales hymenorum novellissorum, et extemplo evanescente, apothecia matura demum difformia et sulcata, supra 1–4 vel rare pluribus sulcis extentis in varias partes, primum vadosis demum diffindentibus apothecium in 2–5 partes multiformes, sicut apothecia plura et difformia conglomerata; spores 8, decolores, non septatae, oblongo-ellipsoideae vel ellipsoideae, 9.5–11 × 4.5–5 μ.

Thallus of small, round to slightly irregular, often scattered, greenish gray to dirty brown or darker warts; apothecia small to middle-sized, 0.4–1.8 mm. across, adnate, the disk slightly to strongly convex, light to darker brown, the exciple thin, surrounded by a very thin thalloid veil, exciple and veil obscurely visible at the basal margins of very young hymenia, but disappearing very early, the mature apothecia becoming variously irregular in form and furrowed above with 1–4 or rarely more furrows running in va-

rious directions sometimes intersecting, at first shallow, but finally splitting the apothecium into about 2–5 variously shaped, closely-placed portions, giving the appearance of as many peculiarly shaped, conglomerate apothecia; hypothecium and hymenium hyaline to pale yellowish; paraphyses stout, somewhat gelatinized and semidistinct, rarely branched above, enlarged toward the apices where sometimes tinged brownish; asci broadly clavate and sometimes saccate; spores 8, hyaline, non-septate, oblong-ellipsoid to ellipsoid, 9.5–11 × 4.5–5 μ.

The algal host is *Protococcoid.*

On a granite boulder in an open pasture near Eaton, Montgomery County, Ohio, collected by Bruce Fink, No. *247,* April 10, 1914 (type), Fink Herb. No. *7980.*

Belonging to the *Biatora*-like section of *Lecidea* with soft and light-colored hypothecium. Similar to *L. sylvicola* Flot., but easily separated by the larger and deeply furrowed apothecia and the larger spores.

6. **Bilimbia Pammellii** Fink, sp. nov.

Thallus granulosus, contiguus vel dispersus, virescenti-glaucus, formans tenuem crustam rimosam; apothecia parva vel mediocria, 0.3–0.7 mm. lata, adnata, dispersa vel rare aggregata, disco convexo, nigro, excipulo concolori et mox exanescente; sporae 8, decolores, oblongo-ellipsoideae, 3 septatae, 15–24 × 3–4.5 μ.

Thallus granulose, continuous or scattered, greenish gray, becoming a thin, chinky crust; apothecia small to middle-sized, 0.3–0.7 mm. across, adnate, scattered or rarely clustered, the disk slightly to strongly convex, black, the exciple of the same color and soon disappearing; hypothecium pale brown; hymenium hyaline; paraphyses unbranched, somewhat thickened at the apices; asci clavate; spores 8, hyaline, oblong-ellipsoid, 3-septate, 15–24 × 3–4.5 μ.

The algal host is *Protococcoid.*

On sandstone at The Ledges, Boone County, Iowa, collected by Bruce Fink, July 27, 1903 (type), Fink Herb. No. *6680.*

Similar to *B. sphaeroides* (Dicks.) Koerb. and *B. epixanthoides* (Nyl.) Lettau, but differing from the latter which has a powdery yellowish thallus and from the former in the slightly heavier thallus and the smaller apothecia with black disk.

7. **Cladonia cristatella densissima** Fink, subsp. nov.

Squamae quam in f. typica crassiores, minores et minus lobatae, demum imbricatae in 3–4 ordines; podetia abortiva vel brevissima, rare plus quam 3–4 mm. longa, dense squamulosa, squamis infimis magnitudine communibus, superioribus minoribus et supernis interdum verruciformibus; apothecia minuta, 0.1–0.4 mm. lata, plerumque aggregata in apice podetiorum, sed nonnumquam in lateribus er interdum in squamis thalli.

The squamules thicker, rather smaller and less lobed than in the species, closely packed and becoming imbricated in 3 or 4 layers; podetia abortive or very short, scarcely surpassing 3 or 4 mm. in length, densely covered with squamules, the basal ones of ordinary size and the upper ones reduced and sometimes passing into wart-like bodies toward the apex; apothecia minute, 0.1–0.4 mm. across, mostly grouped at the apex of the podetia but sometimes occurring on the sides as well and sometimes even seated on the squamules of the primary thallus.

On top of post in dry pasture, near Oxford, Ohio collected by Bruce Fink, March 30, 1927 (type), Fink Herb. No. *15,494*.

8. **Cladonia Herrei** Fink, sp. nov.

Thallus primarius ex squamis parvis vel mediocribus constans, plerumque elongatis et demum aliquoties alte lobatis, plerumque ascendentibus, planis vel leviter involvatis, aggregatis vel dispersis et interdum evanescentibus, viridule glaucis vel umbrinis, lobis saepe crenatis; infra albidis; podetia in squamis primarii thalli formata aut in podetiis morientibus, KOH + (suffusca), longa et gracilia, erecta aut ascendentia, cylindrica, pluries subdichotome ramosa, squamis destituta aut plus minusve squamosa, interdum ommino, squamis sursum multo minoribus et rotundatis, vix lobatis, cortex subcontinuus vel demum dispersus aut confragosus et subareolatus, areolis continuis aut demum rare subdispersis, lateribus et axibus rare perforatis, sterilibus apicibus furcatis, acutis in spinulam desinentibus, interdum perforatis, viridule glaucis vel olivaceo-fuscis, rare scyphiferis; scyphi parvi; apothecia parva, 0.3–0.6 mm. lata, in vel sub terminos ramorum obtusorum aut rare in marginibus scyphorum, saepe aggregata aut conglomerata, disco valde convexo vel subsphaeroideo, pallido vel obscure fusco aut demum nigricante; sporae 8, decolores, non septatae, ellipsoideae, 8–11 × 2.5–3.5 μ.

Primary thallus composed of small to middle-sized, usually elongated and finally several times deeply lobed, commonly ascending, flat to slightly inward-rolled, clustered or scattered and sometimes disappearing, greenish gray to brownish squamules, their lobes often crenate; whitish below; podetia arising from the squamules of the primary thallus or from dying podetia, KOH + (brownish), long and slender, erect or ascending, subdichotomously

much spreading branched, without squamules or more or less squamulose, sometimes throughout, the upper squamules much smaller and almost round, with little or no lobing, the cortex subcontinuous to chinky or rough and subareolate, the areoles continuous or finally and rarely somewhat scattered, the sides and axils rarely perforate, the sterile tips forked and spinous pointed, sometimes perforate, greenish gray to olive brown, very rarely cup-bearing; cups small; apothecia small, 0.3–0.6 mm. across, on or below the ends of the obtuse branches or very rarely on the margins of the cups, commonly clustered or conglomerate, the disk strongly convex to subspherical, light to darker brown, or finally blackish; hypothecium hyaline; hymenium hyaline below and brownish above; paraphyses hyaline, unbranched or branched toward the somewhat enlarged brownish tips; asci clavate with the apical wall thickened; spores 8, hyaline, ellipsoid, non-septate, 8–11 × 2.5–3.5 μ.

The algal host is *Pleurococcus.*

In crevices of rocks in the foothills of the Santa Cruz Mountains, California, collected by A. C. Herre, August 14, 1903, Fink Herb. No. *6502* (type) and No. *6631.*

Doctor Herre published this as *Cladonia furcata racemosa* (Hoffm.) Floerke, in Proc. Wash. Acad. Sci. **7**: 391. 1906. Similar to *C. subsquamosa* (Nyl.) Vainio but without the characteristic powdery-squamulose surface of that species. Note in Prof. Fink's handwriting on the herbarium packet reads, " Scriba says hardly *C. subsquamosa;* the surface similar to *C. degenerans lepidota* Nyl." The last named subspecies has been placed by Vainio under *C. gracilescens* (Floerke) Vainio. Though the surface is similar, the plant is much smaller. It is also similar to *C. rangiformis* Hoffm., but usually smaller and squamulose.

9. **Acarospora immersa** Fink, sp. nov.

Thallus tenuis, levis vel minute rimosus et areolatus, obscure viridi-glaucus vel niger; apothecia minuta, 0.1–0.15 mm. lata, immersa, solitaria aut rare plura in areola, disco plano, canescenti-pruinoso, excipulo tenui et concolori thallo, integro; sporae numerosae, decolores, ellipsoideae, non septatae, 3–4 × 1.5–2 μ, inconditae.

Thallus thin, smooth to minutely chinky and areolate, dark greenish gray to black; apothecia minute, 0.1–0.15 mm. across, immersed 1 or rarely more in an areole, the disk flat, grayish pruinose, the exciple thin, colored like the thallus, entire; hypothecium and

hymenium hyaline; paraphyses hyaline, coherent and semidistinct; asci clavate and becoming inflated; spores numerous, hyaline, ellipsoid, non-septate, 3–4 × 1.5–2 μ, irregularly arranged.

The algal host is *Protococcus*.

On limestone in grassy, open pasture near Oxford, Ohio, collected by Bruce Fink, May 15, 1927 (type).

Similar to the one specimen (Fink Herb. No. *8888*, identified by A. Zahlbruckner) of *A. heppii* Naeg. seen from the United States, but differing in the pruinose disk of the apothecium and the smaller spores.

10. Acarospora saxicola Fink, sp. nov.

Thallus squamosus, squamis parvis vel mediocribus, difformibus, interdum lobatis, demum imbricatis et formantibus crustam crassam et inaequalem, areolatam, glaucam aut sordide albidam, substrato plus minusve tenaciter adjunctam; apothecia parva vel mediocria, 0.4–1.2 mm. lata, immersa vel adnata, 1 aut plura in areola aut in squama, disco plano vel leviter convexo, fusco vel suffusce nigre aut canescenti-pruinoso, excipulo tenui, concolori thallo, integro vel leviter inaequali et crenulato; sporae numerosae, decolores, sphaeroideae, non septatae, 2.5–4.5 μ lata, inconditae.

Thallus squamulose, the squamules small to middle-sized, irregular, sometimes lobed, becoming imbricated and passing into a thick, irregular, areolate, grayish or dirty white crust, more or less closely attached to the substratum; apothecia small to middle-sized, 0.4–1.2 mm. across, immersed to adnate, 1 or more in an areole or squamule, the disk flat to slightly convex, brown to brownish black or grayish pruinose, the exciple thin, colored like the thallus, entire to slightly irregular and crenulate; hypothecium hyaline or cloudy; hymenium hyaline to brownish above; paraphyses hyaline, unbranched, jointed, becoming somewhat conglutinate; asci clavate, becoming inflated, the wall much thickened especially above; spores numerous, hyaline, spherical, non-septate, 2.5–4.5 μ in diameter, irregularly arranged.

The algal host is *Protococcus*.

On rocks at 5400 feet, Naturita, Montrose County, Colorado, collected by Edwin B. Payson, July 1914 (type).

Similar to *A. Scheicheri* (Ach.) Mass., differing in substratum, in the color of the thallus which also often passes into a thick uneven crust, in the sometimes pruinose disk and the slightly smaller, more spherical spores.

11. **Pertusaria lecanina nigra** Fink, subsp. nov.

Apothecia demum obscure nigra vel nigricanti-pruinosa; sporae 2, decolores, ellipsoideae, 100–128 × 40–50 μ.

Apothecia becoming dull black or blackish pruinose; spores 2, hyaline, ellipsoid, 100–128 × 40–50 μ.

On old yew tree at 3000 feet, Rost Lake, Montana, collected by W. P. Harris, July 15, 1901 (type).

12. **Lecanora bipruinosa** Fink, sp. nov.

Thallus crassus, adnatus, pallide fuscus, disperse albido-pruinosus, parte centrali partim rimosus vel subareolatus aut verrucosus et partim lobatus (distincte ad margines), lobis convexis, plus minusve transversaliter ruptosulcatis, aliquantum brevibus, marginibus integris vel incomposite et crasse fluctuoso-crenatis, apicibus interdum nigricanti-tinctis; apothecia parva vel mediocria, 0.5–2 mm. lata, subsessilia, disco plano vel leviter convexo, flaventi-viridi-pruinoso, excipulo concolore thallo, primum crasso, prominenti, integro et roundato, demum rimoso-crenulato, flexuoso, partim vel fere omnino evanescente; sporae 8, decolores, oblongo-ellipsoideae, non septatae, 10–14 × 6–7.5 μ.

Thallus thick, closely adnate, light brown, whitish pruinose over small portions here and there, the central portions partly chinky to subareolate or warty, and in part lobulate, distinctly lobed toward the margins, the lobes slightly to strongly convex, transversely more or less broken-furrowed, rather short, their borders entire to irregularly and coarsely wavy-crenate, the tips sometimes tinged blackish; apothecia small to middle-sized, 0.5–2 mm. across, subsessile, the disk flat to slightly convex, pale yellowish green pruinose, the exciple colored like the thallus, at first thick, raised, entire and round, becoming cracked-crenulate, flexuous, and partly or nearly disappearing; hypothecium and hymenium hyaline; paraphyses stout, several-septate, rarely branched toward the enlarged but scarcely colored apices; asci broadly clavate; spores 8, hyaline, oblong-ellipsoid, non-septate, 10–14 × 6–7.5 μ.

The algal host is *Protococcoid.*

On northward facing tuff at 2450 feet, near Tucson, Arizona, collected by J. C. Blumer, April 1908 (type), Fink Herb. No. *5955.*

Similar to *L. muralis* (Schreb.) Rabenh., but differing in the more irregular and whitish pruinose thallus and the pale green pruinose apothecia.

13. **Lecanora pallida prolifera** Fink, subsp. nov.

Apothecia mediocria, demum proliferata.

Apothecia middle-sized, becoming proliferate.

On trees on Mt. Pinnacle, South Carolina, collected by H. A. Green, July 12, 1886 (type), Fink Herb. No. *613*.

14. **Lecanora Sambuci minnesotensis** Fink, subsp. nov.

Excipulum demum flexuosum et evanescens; disco tum valde convexo et rupto in 2–8 areas convexas, velut ex totidem minutissimis apotheciis conglomerato.

Exciple becoming flexuous and disappearing, the disk in this condition strongly convex and broken into 2–8 convex areas, giving the appearance of as many, very minute conglomerate apothecia.

On balsam trunks about Grand Portage, Minnesota, collected by Bruce Fink, June 19, 1897, No. *25* (type), Fink Herb. No. *2318*. and again on August 12, 1902, Fink Herb. No. *5201*.

15. **Lecanora iowensis** Fink, sp. nov.

Thallus tenuis, glaucus vel canescens, subtiliter albido-pulverulentus, rimosus vel areolatus, areolis parvis, planis, rare lobatis; apothecia minuta vel parva, 0.25–0.7 mm. lata, immersa vel adnata, 1–2 in areola, disco leviter concavo vel plano, pallide vel obscure fusco vel nigricanti, velo canescenti-pruinoso et persistenti, excipulo integro, demum subflexuoso, concolore thallo vel obscuriore; sporae 8, decolores, oblongo-ellipsoidese, non septatae, 10–14 × 5–8 μ.

Thallus thin, greenish gray to ashy, finely whitish pulverulent, chinky to areolate, the areoles small and flat, rarely lobed toward the margins; apothecia minute to small, 0.25–0.7 mm. across, immersed to adnate, 1–2 in each areole, the disk slightly concave to flat, light to darker brown or blackish, beneath a persistent grayish white pruinose cover, the exciple entire, becoming somewhat flexuous, colored like the thallus or darkening; hypothecium and hymenium hyaline; paraphyses distinct, stout, enlarged and rarely branched toward the apices; asci clavate; spores 8, hyaline, oblong-ellipsoid, non-septate, 10–14 × 5–8 μ.

The algal host is *Protococcoid*.

On calcareous rocks near Fayette, Iowa, collected by Bruce Fink, April 1894 (type), Fink Herb. No. *2305*.

This plant was distributed by Prof. Fink under the name of *L. calcarea* (L.) Sommerf. A plant collected by Hall in Kansas and named *L. calcarea* was examined by Prof. Fink from the Tuckerman Collection of the Farlow Herbarium at Harvard University, and was found to be the same. Similar to *L. calcarea* but differing in the finely pulverulent thallus, the somewhat smaller apothecia and the smaller spores consistently 8 to the ascus. Also similar to *L. dispersa* (Pers.) Rolh., but differing in the more persistent thallus and the pruinose apothecia.

16. **Parmelia Finkii** Zahlbr. sp. nov.

Thallus parvus, adnatus, glaucus vel canus, subtus niger et confragosus, ramulis parvis et coralloideis, lobis demum elongatis et ramosis, apicibus integris aut rare crenatis; rhizoideis parvis et dispersis; apothecia parva, 2–3 mm. lata, disco concavo, fusco, excipulo crenato aut obscure coralloideos ramulos ferente; sporae 8, decolores, oblongo-ellipsoideae, non septatae, 8–11 × 5–6 μ.

Thallus small, adnate, greenish gray to ashy, bearing small coralloid branchlets of the same colors, the lobes becoming moderately elongated and laterally branched, sometimes imbricated, the tips entire or rarely crenate, often narrowed; black and roughened below, with few and scattered obscure rhizoids; apothecia small, 2–3 mm. across, the disk concave, chestnut-brown, the exciple crenate or bearing obscure coralloid branchlets; hypothecium hyaline to slightly brownish; hymenium hyaline or brownish below; paraphyses rarely branched; asci clavate; spores 8, hyaline, oblong-ellipsoid, non-septate, 8–11 × 5–6 μ.

The algal host is *Protococcus*.

On trees and mosses over trees, Williamsville, Wayne County, Missouri, collected by Colton Russell, March 1898 (type), Fink Herb. No. *8943*. Named and described by Dr. A. Zahlbruckner in a letter but unpublished as far as known.

Similar to *P. carolinana* Nyl. and *P. latissima* (Mont.) Fee, but differing in the thallus which is smaller than either, and having smaller spores.

17. **Caloplaca oxfordensis** Fink, sp. nov.

Thallus tenuis vel crassus, formatus e granulis minutis, planis vel convexis, sordide canescenis, dispersis vel coalescentibus in continuam areolatum crustam; apothecia minuta vel parva, 0.1–0.4 mm. lata, adnata vel subsessilia,

disco leviter concavo vel plano vel convexo, luteo vel fusco, excipulo tenui; sporae 8, decolores, ellipsoideae vel oblongo-ellipsoideae, 1-septate, loculis polaribus, 13–16 × 5.5–8 μ.

Thallus thin to moderately thick, composed of minute, flat to convex, dirty gray to darkening granules, scattered or crowded into a continuous, areolate crust; apothecia minute to small, 0.1–0.4 mm. across, adnate to subsessile, often crowded and irregular, the disk slightly concave to flat or somewhat convex, orange to brown or dusky, the thalloid exciple rather thin, orange to darker, becoming flexuous; hypothecium and hymenium hyaline; paraphyses septate, unbranched and free, more or less enlarged at the apices; asci clavate; spores 8, hyaline, ellipsoid to oblong-ellipsoid, 1-septate, the cells polar, 13–16 × 5.5–8 μ.

The algal host is *Protococcus*.

On exposed rocks near Oxford, Ohio, collected by Bruce Fink, August 9, 1909 (type).

Similar to *C. citrina* (Hoffm.) T. Fries and to *C. sideritis* (Tuck.) Fink, but differing from the latter by the somewhat thinner thallus and the smaller apothecia, from the former in the color of the thallus which is also more scattered in this species.

18. **Blastenia novomexicana** Fink, sp. nov.

Thallus formatus e squamis minutis vel parvis, convexis, granulosis viridiflaventibus vel luteis, coalescentibus in plus minusve continuam crustam; apothecia parva, 0.3–0.6 mm. lata, subsessilia, disco plano vel leviter convexo, luteo, excipulo proprio tenui, pallido aut rare concolori disco; sporae 8, decolores, oblongo-ellipsoideae, demum 1-septate, loculis polaribus 12–16 × 6–7.5 μ.

Thallus composed of minute to small, convex, greenish yellow to orange, granulose squamules, running together into a more or less continuous crust; apothecia small, 0.3–0.6 mm. across, subsessile, the disk flat to slightly convex, orange, the proper exciple thin, lighter or more rarely colored like the disk; hypothecium and hymenium hyaline; paraphyses unbranched, becoming enlarged and slightly colored at the apices, rarely and indistinctly septate; asci clavate; spores 8, hyaline, oblong-ellipsoid, becoming 1-septate, the cells polar, 12–16 × 6–7.5 μ.

The algal host is *Protococcus*.

On granite rocks near Las Vegas, New Mexico, collected by Brother Anect, November 12, 1925 (type), Fink Herb. No. *15,480*.

Similar to *B. lobulata* (Floerke) Fink and *B. modesta* (Zahlbr.) Fink, but without the marginal lobing of the thallus as found in these, and with longer spores.

19. **Rinodina kentuckyensis** Fink, sp. nov.

Thallus tenuis, levis vel minute granulosus, continuus vel dispersus, sordide canescens vel obscure niger; apothecia minuta, 0.1–0.25 mm. lata, numerosa, rotundata vel subdifformia, partim immersa vel adnata, disco concavo vel fere plano, obscure nigro vel canescenti-pruinoso, excipulo crassiusculo, integro, prominenti, concolori thallo; sporae 8, fuscae, oblongo-ellipsoideae, 1-septatae, plerumque constrictae ad septum, 15–18 × 7.5–8.5 μ, inconditae.

Thallus thin, smooth to minutely granulose, continuous or scattered, dirty gray to dull black; apothecia minute, 0.1–0.25 mm. across, numerous, round to somewhat irregular when crowded, partly immersed to adnate, the disk concave to almost flat, dull black or slightly grayish pruinose, the exciple rather thick, entire, prominent, colored like the thallus; hypothecium and hymenium hyaline; paraphyses slender, hyaline, enlarged and usually brownish toward the apices; asci clavate to broadly clavate, the wall conspicuously thickened in the apical region; spores 8, brown, oblong-ellipsoid, 1-septate, usually constricted, 15–18 × 7.5–8.5 μ, irregularly arranged.

The algal host is *Protococcus*.

On sandstone rocks in Kentucky, collected by Bruce Fink, September 4, 1912 (type).

Similar to *R. nigra* Fink, but the thallus sometimes becoming darker, the apothecia slightly smaller and the spores longer.

20. **Rinodina microbola** Tuck. sp. nov.

Thallus tenuis, crasse areolatus, canus vel candidus, areolis dispersis aut contiguis; apothecia minuta vel parva, 0.15–0.4 mm. lata, partim immersa vel adnata, disco plano vel convexo, nigro, excipulo tenui; sporae 8, fuscae, ovoideo-ellipsoideae, 3 transverse septatae et raro 1 longitudinale septatae, 13–22 × 7–11 μ.

Thallus thin, coarsely areolate, ashy to whitish, the areoles scattered or continuous; apothecia minute to small, 0.15–0.4 mm. across, partly immersed to adnate, the disk flat to convex, black, the exciple thin, colored like the thallus; hypothecium yellowish to brownish; hymenium hyaline to brownish above; paraphyses semidistinct, appearing to be somewhat branched; asci inflated-clavate; spores 8, brown, ovoid-ellipsoid, 3-septate transversely and becoming 1-septate longitudinally, 13–22 × 7–11 μ.

The algal host is *Protococcus*.

On rocks in California, the specimen bearing no collector's name or date of collection, Fink Herb. No. *11,233* (type). Also Tuckerman is given as the author but no published description has been found.

Similar to *R. conradi* Koerb., but differing in the areolate thallus and the spores which here show a submuriform condition.

21. **Rinodina bolodes** Tuck. sp. nov.

Thaluus crassus, granulosus, granulis parvis, flaventibus vel canescentibus; apothecia parva vel mediocria, 0.5–1.2 mm. lata, sessilia, disco plano vel convexo, nigro vel canescenti-pruinoso, excipulo crasso; sporae 8, fuscae, ellipsoideae vel ovoideo-ellipsoideae, 1-septatae, 14–20 × 6–8.5 μ.

Thallus thick, composed of small, coarse, yellowish to gray, convex, crowded granules; apothecia small to middle-sized, 0.5–1.2 mm. across, sessile, the disk flat to convex, black or grayish pruinose, the exciple thick, colored like the thallus, becoming flexuose; hypothecium yellowish; hymenium hyaline to brownish above; paraphyses slender, unbranched, becoming semidistinct; asci clavate; spores 8, brown, ellipsoid to ovoid-ellipsoid, 1-septate, 14–20 × 6–8.5 μ.

The algal host is *Protococcus*.

On soil, near San Diego, California, collected by C. R. Orcutt, Fink Herb. No. *11,228* (type). The specimen bears a name with Tuckerman as the author but no published description has been found.

Similar to *R. turfacea* (Wahl.) T. Fries, but differing in the much smaller spores.

22. **Rinodina ochrocea** Willey, sp. nov.

Thallus tenuis, rimoso-areolatus, areolis minutis vel parvis, inaequalibus, continuis, flaventi-canescentibus vel fuscis; apothecia minuta vel parva, 0.2–0.4 mm. lata, immersa vel adnata, disco concavo, nigro, excipulo crassiusculo; sporae 8, fuscae, oblongo-ellipsoideae, 1-septatae, 20–25 × 9–11 μ.

Thallus thin, chinky-areolate, the areoles minute to small, irregular, continuous, yellowish gray to brownish; apothecia minute to small, 0.2–0.4 mm. across, immersed to adnate, more or less crowded, round to irregular, the disk concave, black, the exciple rather thick, colored like the thallus, more or less uneven; hypothecium and hymenium hyaline; paraphyses slender, branched; asci

clavate; spores 8, brown, oblong-ellipsoid, 1-septate, 20–25 × 9–11 μ.

The algal host is *Protococcus*.

On rocks, Chester County, South Carolina, collected by H. A. Green. The specimen bears no date of collection. It is marked " from the type." Willey is given as the author, but no published description has been found.

Similar to *R. sophodes* (Ach.) Koerb., but differing in the lighter-colored thallus and the longer spores.

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DASYSCYPHAE ON CONIFERS IN NORTH AMERICA. II. D. ELLISIANA

GLENN GARDNER HAHN AND THEODORE T. AYERS

(WITH PLATES 21–23)

INTRODUCTION

When the European larch canker disease, caused by *Dasyscypha Willkommii* (Hart.) Rehm was discovered in this country, considerable apprehension was felt concerning the introduced fungus, because of reports from Europe attributing the organism to be a parasite of Douglas fir [*Pseudotsuga taxifolia* (LaM.) Brit.]. This apprehension was increased when cankered Douglas firs associated with a related *Dasyscypha* species were discovered in New England (1928) by Howard (**3**) shortly after the European larch canker disease was found in the United States. In certain instances these diseased Douglas firs were growing in close proximity to the imported European larch infected with *D. Willkommii*. Accordingly it became necessary to investigate the pathology of the new Douglas fir disease, as well as the taxonomy of the *Dasyscypha* forms commonly occurring on this economically important conifer, in order to determine their relationship to *D. Willkommii*.

In a previous study, described in the first paper of a series dealing with North America coniferous *Dasyscyphae* (**2**), investigation has shown that the European larch canker parasite does not attack Douglas fir, but the closely related saprophyte, *D. calycina* Fuckel (nec *Peziza calycina* Schum.), may fruit sparingly on dead, or weakened and dying tissue of that host. The present paper, which is second in the series mentioned, gives the results of a related research in which *D. Ellisiana* (Rehm) Sacc., the fungus commonly fruiting in association with the Douglas fir disease, is shown to be a native species. This fungus, which has generally been regarded as a harmless saprophyte on pine, has become parasitic upon introduced species of pine and Douglas fir in New England. The taxonomic detail given, indicates the relationships of *D. Ellisiana*. Data, which have shown the organism to

be a parasite when artificially inoculated into healthy Douglas fir, will be presented in a separate paper dealing with the pathological aspects of the problem.

HISTORY AND DESCRIPTION OF DASYSCYPHA ELLISIANA (REHM) SACC.

Dasyscypha Ellisiana was described in 1876 by Rehm (**6**) as *Peziza Ellisiana* n. sp., from material collected by Ellis (1875) on the bark of *Pinus rigida* Mill in New Jersey. It was subsequently transferred to the genus *Dasyscypha* in 1889 by Saccardo with the following synonyms: *P. Ellisiana* Rehm; *P. calycina* Schwz. in Herb. Soc. Nat. Phila., sec. Ellis.

Rehm had distributed type specimens of the new American organism as Ascomyceten n. *303* (7th fasciculus, published 1876). Later, however, he changed his mind about his fungus, and in making the combination *Dasyscypha lachnoderma* (Berk.) Rehm, for Berkeley's new species, *P. lachnoderma* (1860) from Tasmania (**1**), he considered the American plant as a synonym of the fungus collected in the southern hemisphere. Rehm probably came to this decision because of statements made by Cooke, who suggested that the two names were synonymous for the same fungus, soon after Rehm described *P. Ellisiana.* Cooke figured (Grevillea **4**: 171–2, *pl. 66, fig. i,* 1876) a specimen collected in South Carolina and identified as *P. calycina* by Curtis. From Cooke's illustration and accompanying notes, it is apparent that Curtis' fungus was nearly related to *D. Ellisiana,* and certainly not *Dasyscypha calycina* Fuckel. (**2**). It was Cooke's opinion, however, that Curtis' fungus seemed to be *P. lachnoderma* although he did not commit himself, for the reason that he had not seen Rehm's new species, *P. Ellisiana.* In September of the same year, Cooke (Grevillea **5**: 37, 1876) stated that Phillips had communicated to him that the spores of *P. Ellisiana* agreed perfectly with those of *P. lachnoderma* Berk. Rehm apparently was governed by these opinions for when he came to distribute his "Schedula rectificata," he changed the label for "Ascom. *303 Dasyscypha Ellisiana* Rehm, in litt. ad. cl. Cooke, on *Pinus* Rinde, Newfield, N. J., N. Amerika 12/1875, J. B. Ellis,"—to "*Dasyscypha lachnoderma* (Berk. sub *Peziza*)" and referred to Cooke's observations.

Saccardo perpetuated the error when he gave Rehm's rectified specimen, Ascom. n. *303 Peziza lachnoderma,* as the exsiccatum for *Dasyscypha lachnoderma* (**7**, p. 433). At the same time Saccardo (**7**, p. 459) made the new combination *D. Ellisiana,* based upon Rehm's *P. Ellisiana,* citing the original description but not mentioning the type, Ascom. n. *303.*

Berkeley's *P. lachnoderma* (1860) was redescribed by Massee (**5**) with the synonym *Dasyscypha lachnoderma* (in part) according to Rehm, because of the latter's change of opinion with regard to *Peziza Ellisiana.* Massee, however, recognized Ellis' New Jersey fungus as a species quite distinct from Berkeley's species from Tasmania.

Since there has been so much confusion in the past regarding the identity of *Dasyscypha Ellisiana* and since certain American mycologists continue to use the name of the Tasmanian fungus for the native plant, it is important because of the pathological significance of the organism, to give at this time a complete description and indicate wherein it differs from the foreign fungus:

DASYSCYPHA ELLISIANA (Rehm) Sacc., desc. emend.

Syn.: *Peziza Ellisiana* Rehm, in Grevillea **4**: 169. 1876.

P. calycina Fries (Herb. Soc. Nat. Phila.).

Dasyscypha lachnoderma (Berk.) Rehm, pro parte, Ascom. *303;* Sacc. Syll. **8**: 433, 1889.

D. Ellisii Rehm.

Helotium Ellisianum Wettstein.

Apothecia commonly gregarious (PLATE 21, FIGS. 1, 2; PLATE 23, FIGS. 3, 4), or scattered, shortly but distinctly stipitate; stem white (not black at base); at first pyriform, margin incurved and closed, then expanding when fully mature becoming nearly plane, with corrugated margin more or less upraised (PLATE 21, FIG. 1), silky margin incurved when dry, fringed with fasciculate hairs; externally pure white or yellow to yellowish-green, densely downy; hairs elongate, flexuous, filamentous, septate, hyaline, smooth, with short cells, sometimes swollen or bulbous, 10–18 × 2–5 μ, thin-walled, cylindrical, obtuse, persistent, (PLATE 22, FIG. 1); disc light orange-yellow to deep chrome,[1] 0.5–2 mm. diam., commonly 1 mm. diam.

[1] The color nomenclature used is that of R. Ridgway, Color standards and color nomenclature, 1912, Wash., D. C.

Asci clavate, short-stalked, obtuse, (100) 54–72 × 5.5–7.0 μ (PLATE 22, FIG. 3). Ascospores 8, irregularly biseriate, hyaline, smooth, continuous at first, unicellular or uniseptate upon germination, (PLATE 21, FIGS. 3, 4), straight, fusiform, ends acuminate, (100) 16.0–27.9 × 1.4–2.9 μ, commonly, 17–21 × 2–2.5 (PLATE 22, FIG. 5). Paraphyses filamentous, straight or slightly flexuous (see Cooke, Grevillea **4**: *pl. 66, fig. i*), septate, obtuse or acuminate at tips, (100) 72–90 × 1–2 μ (PLATE 22, FIG. 3) occasionally somewhat broader above with the tip narrowed.

Imperfect stage abundant, yellowish-green, minute, consisting of an erumpent stroma, 106–132 μ diam., at first closed, then opening up with a single exposed chamber (PLATE 23, FIG. 1) or compound, with more than one locule, 243–433 μ diam. (PLATE 23, FIG. 2). Microconidia fusiform, 5.0–5.8 × 0.9–1.2 μ (PLATE 22, FIG. 7) abstricted from the tips of short sporophores, subulate, acute, simple or verticillately branched (PLATE 22, FIG. 6).

The imperfect stage, which is here reported for the first time, was found commonly in New England during the summer, followed by the perfect stage which formed during the autumn and winter. However, ascocarps containing spores could be collected throughout the entire year. With age the hymenium was observed to disintegrate, or was eaten out by insects leaving behind the excipular shells of the fruit cups. These persisted (PLATE 23, FIG. 4) and could be recognized readily as bleached, white remnants tinged with deep glaucous-green or light porcelain-green, with which the new immature ascocarps were associated.

The hosts upon which *D. Ellisiana* has been found and their distribution according to states are grouped together in the following list:

On Abieteae. *Larix europaea* D. C.,—N. Y., R. I.; *Larix leptolepis* Murr.,—Mass.; *Picea Engelmanni* Engelm.,—Mass.; *P. pungens* Engelm.,—Mass.; *Pinus austriaca* Asch. & Graebn.,—Conn., N. J.; *P. Banksiana* Lamb.,—Conn., Mass., R. I.; *P. Cembra* L.,—Conn.; *P. echinata* Mill.,—N. Car.; *P. flexilis* James,—Mass.; *P. monticola* D. Don.,—Mass.; *P. nigra Poiretiana* Asch. and Graebn.,—Ohio; *P. ponderosa* Lawson,—Mass.; *P. pungens* Lamb.,—N. Car.; *P. resinosa* Sol.,—Conn., Maine, R. I.; *P. rigida* Mill.,—Conn., Maine, Mass., N. J., N. Car., Pa., W. Va.;

P. Strobus L.,—Maine, Mass., N. J., N. C., Pa., R. I.; *P. sylvestris* L.,—Mass., N. J., Pa., R. I; *P. taeda* L.,—Del., La., N. J.; *P. virginiana* Mill.,—Md., Pa., Va.; *Pinus spp.*,—Ala., Miss., Fla., S. Car., Texas; *Pseudotsuga taxifolia* (LaM) Brit., blue form,—Mass., N. Car., R. I.

Exsiccata examined:

Besides the numerous collections filed in the collections of the Division of Forest Pathology at New Haven, Conn., the writers have examined the following herbarium specimens collected on various hosts in North America and found them to be *Dasyscypha Ellisiana.* In many instances these specimens previously had been identified as *D. lachnoderma.*

Peziza calycina Fries, Syn. Car. *1207, vulgaris* Bethlehem *55,* on pine bark, Schweinitz Herb. *1831* (Phila. Acad. Nat. Sci.).

Peziza calycina, on bark of pine, Houston, Texas, *171,* H. W. Ravenel, 1869 (Herb. Myc. B.P.I., U.S.D.A.). According to an annotation on the specimen packet, Dr. W. W. Diehl had identified this specimen as *D. Ellisiana.* We did not examine the poor material microscopically but macroscopically the fungus appears to be that species.

Peziza lachnoderma Berk. on pine branches, Aiken, S. C., *175* Ravenel, Fungi Am. (N. Y. Bot. Gard.).

Dasyscypha lachnoderma (Berk. sub. *Peziza*), Schedula rectificata, Ascom. n. *303, Dasyscypha Ellisiana* Rehm, on pine bark, Newfield, N. J., coll. J. B. Ellis, Dec. 1875 (N. Y. Bot. Gard.).

Peziza Ellisiana Rehm, nov. spec. on *Pinus rigida,* Newfield, N. J., Dec. 1875, n. *716,* Thümen Myc. Univ. (N. Y. Bot. Gard.).

Peziza lachnoderma Berk., on pine bark, Newfield, N. J., July, 1882 in Ellis collection (Herb. N. Y. Bot. Gard.). A specimen *P. Ellisiana* Rehm, coll. Ellis, pine limbs, Newfield, N. J., Jan. 1876, in Remainder Herb. Ellis, purchased C. L. Shear,—bears the following interesting annotation by Ellis who had identified the fungus originally as *P. calycina* Schum.:—" Mr. Peck thinks this is near *Peziza Ellisiana.* Disc pale straw-yellow."

Peziza lachnoderma Berk., = *D. Ellisii* Rehm. = *D. lachnoderma* Rehm on *Pinus* dead branches, Ocean Springs, Miss., Feb. 1, 1887, (Herb. F. S. Earle, N. Y. Bot. Gard.).

Dasyscypha lachnoderma Berk. on *Pinus rigida*, Arlington Hts., Mass., May 21, 1894, (Burt Herb. in Farlow Herb., Harvard Univ.). *D. Ellisiana* was found in this packet although Burt included illustrations of a *Dasyscypha* with oblong spores, 14–17 × 5–6 μ, with the specimen.

Peziza (*Dasyscypha*) *lachnoderma* Berk., bark of dead *Pinus austriaca* (cult.) Newfield, N. J., Dec. 1894. Ellis & Ev. N. Am. Fungi, *3231*. Also, *D. lachnoderma*, N. Am. Fungi, *3231*, Dec., 1894 (N. Y. Bot. Gard.).

Dasyscypha lachnoderma (Berk.) Rehm on *Pinus*, dead bark, Auburn, Lee Co., Ala., July, 1896. Coll. F. S. Earle (N. Y. Bot. Gard.).

Dasyscypha lachnoderma (Berk.) Rehm on pine bark, Auburn, Lee Co., Ala., March 21, 1897. Coll. F. S. Earle, *2236*, Ala. Biolog. Survey (N. Y. Bot. Gard.).

COMPARISON WITH DASYSCYPHA LACHNODERMA (BERK.) REHM

As previously indicated Massee (**5**) had pointed out correctly that *D. Ellisiana* was distinct from *D. lachnoderma*. He emphasized certain important differences: ". . . Dr. Rehm described . . . under the name of *Peziza Ellisiana*, a minute *Peziza* growing on pine bark collected by J. B. Ellis at Newfield, N. J., U. S. A. This species was afterwards issued in Rehm's Ascom. n. *303* as *Dasyscypha Ellisiana* Rehm. Some time afterwards Rehm sent out a new label for his Ascom. n. *303*, in which he substituted the name *Dasyscypha lachnoderma* (Berk.) Rehm. This was unfortunate, as the American plant is quite distinct, differing from *P. lachnoderma* Berk., more especially in the following points: Ascophore smaller, not so distinctly stipitate; stem not black; externally tinged yellowish-green; asci slightly broader, spores shorter and thicker, and in all the specimens I have examined continuous; always growing on bark or wood of conifers. Hence *Peziza Ellisiana* Rehm, must stand as a species distinct from *P. lachnoderma* Berk., with the following synonymy: *Dasyscypha lachnoderma*, Rehm, Ascom. n. *303;* Sacc. Syll. VIII, n. 1804 (in part). . . ." The authors have examined the exsiccata listed by Massee, which he regarded as being *Dasyscypha Ellisiana*, and have confirmed him in his opinion.

In his redescription of Berkeley's *Peziza lachnoderma,* Massee (**5**) reported the fruit bodies of the Tasmanian fungus as being larger than *Dasyscypha Ellisiana,* 3–4 mm. in diameter, and having a stipe which is conspicuously black at the base. This is illustrated by Massee on his original plate of *D. lachnoderma* preserved in the herbarium of The New York Botanical Garden. His notes and drawings made from the type specimen collected by Archer on dead bark in Tasmania (**1**) and deposited at Kew, not only clearly illustrate this particular character, but also give other morphological detail in agreement with his description.

The writers have examined a specimen of *Dasyscypha lachnoderma,* collected by Rodway in Tasmania, from the herbarium of Massee (Herb. N. Y. Bot. Gard.). Their observations on this fungus have confirmed those of the English mycologist. The following morphological characters indicate outstanding dissimilarities with *D. Ellisiana.* The excipular hairs are elongate, flexuous, thin-walled, minutely roughened, with long cylindrical cells (16.0–41.2 × 3.0–4.2 μ) and obtuse extremities (PLATE 22, FIG. 8). In the examination of herbarium material, the character of the hairs was found to be most useful in distinguishing the two species when spores were lacking. The asci (PLATE 22, FIG. 9) are cylindrical, clavate, apex slightly narrowed, long-stalked (20) 68.4–93.6 × 4.0–4.8 μ (Massee gave somewhat shorter measurements,—60–70 × 6–8 μ). The ascospores (PLATE 22, FIG. 10) are irregularly biseriate, hyaline, smooth, crescent-shaped, with acuminate apices, one to three septate, (50) 12.6–24.4 × 1.4–2.4 μ (according to Massee, 23–30 × 2 μ). The paraphyses, which Massee (**5**) described as " very slender, very slightly thickened at the tip, and the point narrowed, delicately septate," were present. These paraphyses, which measured 97–112 × 2–4 μ (PLATE 22, FIG. 9), could be considered lance-like in that they possessed " apice acutae " and were " grandiusculae " in the sense of Karsten's *Lachnum* (**4**).

For the reason that Rehm recognized the genus *Lachnum,* one would naturally expect him to have called the *Peziza lachnoderma* of Berkeley, *Lachnum lachnoderma* (Berk.), instead of *Dasyscypha lachnoderma* (Berk.), when he (Rehm) made that new combination. Rehm probably did not actually examine Berkeley's material and merely based his opinion upon the published statements

of Cooke and Phillips, that his new species, *P. Ellisiana,* agreed with the Tasmanian plant. At the time he made the combination, Rehm no doubt had in mind *P. Ellisiana,* which can be considered a species of *Dasyscypha;* for as Rehm (**6**) had described, it possessed paraphyses which were " filiformes, ascos superantes, septatae, c. 2 μ crass." Because of the broad, acerose paraphyses of *P. lachnoderma,* this species should be transferred to the genus *Lachnum* as **L. lachnoderma** (Berk.) comb. nov.

Inasmuch as *D. Ellisiana* has slender, filamentous, straight or slightly flexuous paraphyses, which possess extremities either obtusely rounded or acuminate, the authors have preferred to keep the species within the genus *Dasyscypha* (**2**). The paraphyses of this species resemble those illustrated for *D. cerina* (Pers.) Fuckel, in Clements and Shear (The Genera of Fungi, *pl. 33,* 1931). *D. Ellisiana* would appear to be a borderline species between those forms having filamentous paraphyses and those producing broad, lanciform structures.

LIFE-HISTORY STUDIES

Since cultures from fresh material of *Lachnum lachnoderma* were not available for study, observations on those made with *D. Ellisiana* can only be reported at this time. Cultures of the American fungus were obtained from diseased tissues of the host (PLATE 23, FIG. 3) and from mono-ascus and -ascospore isolations. The spores germinated readily on 3 per cent malt agar under ordinary laboratory conditions within 48 hours, producing polar germ tubes at one or both ends. The ascospores as in the case of the large-spored, white-excipled *Dasyscyphae* (**2**) became commonly uniseptate or germinated without producing a septum (PLATE 21, FIGS. 3, 4). Cultures were also obtained from single paraphyses (PLATE 22, FIG. 4) or excipular hairs (PLATE 22, FIG. 2) which were found to be capable of continued growth, producing characteristics similar to those obtained in cultures from spore isolations. Cultures obtained in this way gave rise to the formation of the imperfect stage.

On malt-agar, single-spore cultures of *D. Ellisiana* produced a fine, silky, snow-white, aerial mycelium, which in the early stages of the culture had the appearance of " combed wool " (PLATE 21, FIG. 6). It was noted that certain cultures became somewhat appressed and as staling set in, ceased to produce outwardly a vig-

orous vegetative growth (PLATE 21, FIG. 5). In the former type of colony a beautiful sulphur yellow color appeared which changed with age to a light porcelain-green, pale glaucous-green or dusky green-blue. In the latter type of colony, pinkish-buff or cinnamon-buff appeared becoming interspersed with the green shades mentioned. The agar under the mycelial mat was discolored, so that it became tawny, seal brown or plumbeous brown. A physiological difference has been noted among strains of *D. Ellisiana*.

It was discovered that *D. Ellisiana* is able to produce in culture a soluble, non-volatile, thermostable, crystalloidal substance, which formed readily in the presence of certain sugars or fresh Douglas fir extract, but not in the presence of proteins. This non-living constituent which was toxic to Douglas fir and other conifers, causing browning of needles and defoliation, apparently does not inhibit the growth of the organism; for fresh malt agar tubes, whose slant surfaces had been moistened with the toxic substance, when inoculated with the fungus, produced normal growth.

The imperfect stage formed readily from single ascospore cultures. The fruit bodies, however, showed a tendency to become compound under artificial conditions, forming extensive stromatic growth, oozing glaucous-green or dusky green-blue masses of the microconidia or spermatia. The sporophores and conidia produced in culture are of the same type as those formed in nature. Numerous attempts to germinate these conidia have failed. Attempts have also been made to spermatize fresh single ascospore isolation cultures with these microconidia, to induce the formation of the perfect stage but without success. We believe the spermatia germinable although we have not been able to demonstrate this. It is interesting here to note that we failed to obtain germination of the microconidia of *D. Ellisiana* and the four species of the large-spored *Dasyscyphae* (**2**). However, we did succeed in obtaining the germination of the microconidia of species of the *D. calyciformis* group. The small, unicellular ascospores of species belonging to this last-named group, germinated readily without forming a septum, whereas the ascospores of species producing microconidia which did not germinate, formed one or more septa during the germination period.

The imperfect stage of *D. Ellisiana* was found abundantly occurring during the summer. By late autumn the perfect stage,

which persisted into the late spring, had formed among these conidial stromata upon the bark scales of pine, or upon the resinous lesions and bark of the diseased Douglas fir. In southern New England the ascospores were fully mature in May and June.

DISCUSSION

A perusal of the exsiccata examined and reported in this paper will show that while *Dasyscypha Ellisiana* has been widely collected on pine in the eastern United States, it has generally been identified as *D. lachnoderma*. Despite the fact that it has recently been observed occurring commonly on the blue Douglas fir in New England, particularly where this western species is growing in a badly diseased condition (**3**), the occurrence of Ellis' and Rehm's fungus upon this host has heretofore been unrecognized. It is of interest to remark here that Seymour (Host Index of the Fungi of North America, 1929), does not cite *D. Ellisiana* on Douglas fir in his compilation of published fungus records, and where the organism is mentioned, it is reported only on one host. On *Pinus rigida* both *D. lachnoderma* and *D. Ellisiana* are listed; on *P. nigra* and an undetermined species of *Abies*, the former fungus.

As far as we have been able to determine *Lachnum lachnoderma* has been collected only in the southern hemisphere and in Cuba. As previously stated the type came from Tasmania. According to Massee (**5**), "other specimens in the herbarium are from Brisbane (Bailey, nn. *572* and *1804*): Natal (MacOwan, nn. *156, 194, 1126*). The type of *P. melanopus*, Berk. & Curt., from Cuba (Wright, n. *368*), proves to be identical with *P. lachnoderma*. Not any of the specimens mentioned above are growing on bark or wood of conifers."

Apparently in the case of *D. Ellisiana*, we have an instance of a native saprophytic fungus which has become parasitic on introduced Douglas fir, western yellow and limber pines and Swiss stone pine (*Pinus Cembra*) in New England. The species has been known in the literature since the days of Schweinitz (1831) who probably first collected it (**8**). Our pathological research, which has consisted of a very large number of artificial inoculations upon Douglas fir, western yellow pine and eastern and western white pines, has shown the fungus to be parasitic. Cankers have been obtained experimentally, upon which the imperfect and per-

fect stages of the species fruited on the dead cortex. In our inoculation work, strains of *D. Ellisiana* obtained from diseased bark tissue and from mono-ascus and -ascospore isolations were used. As has been pointed out in a previous paper (2), *D. Willkommii,* the European larch canker parasite, unlike *D. Ellisiana,* does not infect either healthy or weakened Douglas fir.

A complete search for the fungus has not been made. However, from miscellaneous collections we know it to occur from Maine to Texas in close proximity to the coast line; for to date it has been collected in only one instance in a locality more than 400 miles inland. Hedgcock collected it on Mt. Pisgah, N. C., which has an elevation of 5,749 feet. *D. Ellisiana* has been taken only once very recently in the midwestern states (*53885, Pinus nigra Poiretiana* Shawnee State Forest, Ohio, coll. R. K. Beattie and Curtis May, May 1, 1933) and not in the far West. The late Ellsworth Bethel and Drs. Seaver and Shope, who have collected Discomycetes widely in Colorado, never came upon it. Mr. J. R. Hansbrough of the Division of Forest Pathology, who collected *Dasyscyphae* for these investigations (2) and who knew *D. Ellisiana* intimately, did not find it either on pine or Douglas fir on the western coast or in the Pacific Northwest (including British Columbia).

D. Ellisiana is not reported from Europe. The senior author in company with Mr. Ivar Jørstad (Skogdirektorens innberetning om det Norske Skogvesen for 1930, p. 88, Oslo, 1931) has observed blue Douglas fir seriously diseased in Norway (Søfteland) in 1927–1928, but the *Dasyscypha* abundantly concerned in this particular instance as a probable parasite, was another species, *D. resinaria* (Cooke & Phill.) Rehm.

SUMMARY

A taxonomic study of *Dasyscypha Ellisiana* (Rehm) Sacc., commonly associated with diseased Douglas fir (*Pseudotsuga taxifolia,* blue form), growing within and outside areas in New England where the European larch canker fungus, *D. Willkommii* (Hart.) Rehm, was found introduced, has shown the organism to be a native species.

D. Ellisiana, which was first collected in 1831 by Schweinitz as *Peziza calycina* Fries, has been generally regarded as a saprophyte

on pine. Recent observations have shown that the organism apparently has become parasitic on four introduced host species in New England—*Pseudotsuga taxifolia* (blue form), *Pinus ponderosa, P. flexilis* and *P. Cembra.*

D. Ellisiana has been frequently confused taxonomically with *D. lachnoderma* (Berk.) Rehm, a non-coniferous Discomycete from Tasmania. These two species, as Massee pointed out, are quite distinct. Morphological data confirming Massee's observations are given setting forth the differences between them together with notes upon life-history studies of *D. Ellisiana.*

An amended description of *D. Ellisiana* is included in which the imperfect stage is reported for the first time. The species is reported on 15 species of pine, on spruce, on larch, and on blue Douglas fir. *D. Ellisiana* occurs along the seaboard from Maine to Texas. It has been collected only once in the Mid-West and not in the far West or in Europe.

D. lachnoderma is now considered as belonging to the genus *Lachnum* and is called *Lachnum lachnoderma* (Berk.) Hahn & Ayers. According to Massee, the fungus occurs in the southern hemisphere and has never been found on the bark or wood of conifers. Cuban material, identified as *Peziza melanopus* Berk. & Curt., is regarded by Massee as identical with the Tasmanian fungus.

We wish at this time to express our appreciation to the officials of Farlow Herbarium, Harvard University, to the Director and Dr. F. J. Seaver of The New York Botanical Garden and to the officials of the Herbarium, Division of Mycology, Bureau of Plant Industry, Washington, D. C., for courtesies and privileges they have accorded us. Also due recognition should be given to Mr. J. R. Hansbrough, Division of Forest Pathology for all the earlier culture isolation studies. To the late Dr. N. O. Howard and to the other members of the same Division who have sent us specimens, we are also grateful.

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8. **Schweinitz, L. D. von.** *Peziza calycina* Fr., Trans. Am. Phil. Soc. **4**: 172. 1831.

EXPLANATION OF PLATE 21

Dasyscypha Ellisiana (Rehm) Sacc.

Fig. 1, Habit, fully mature apothecial material from Potowomut, Rhode Island, collected and photographed by the late Dr. N. O. Howard, March 30, 1928. On bark of cankered *Pseudotsuga taxifolia*, blue form. Approx. × 4; 2, Habit apothecia on hypertrophied bark of diseased Douglas fir material, Potowomut, R. I. Note: clumped growth of over-mature fruiting cups, slowly degenerating, leaving the bleached, whitish excipular shells. Approx. × 4; 3, Germinating ascus, after five days on the surface of malt agar. Approx. × 670; 4, Ascospores showing characteristic polar germ tubes. Approx. × 300; 5, Forty-day-old cultures on malt agar; culture on right from a mono-ascus, in the middle from mono-ascospore (North Beverley, Mass., diseased Douglas fir material *43567*), on the left from mono-ascospore (material from same locality, *43566*). Cultures show staling. Nat. size; 6, Three, 40-day-old mono-ascospore cultures on malt agar (Beverley, Mass. material, *43566*). Nat. size.

EXPLANATION OF PLATE 22

Dasyscypha Ellisiana

All drawings made with camera lucida × 800

Fig. 1, Excipular hairs; 2, Excipular hairs showing vegetative growth. *Pinus resinosa* material on malt agar; 3, Asci and paraphyses; 4, Paraphyses showing vegetative growth. *P. resinosa* material on malt agar; 5, Ascospores; 6, Sporophores, fresh *P. resinosa* material, Potowomut, R. I.; 7, Microconidia (spermatia), culture material from mono-ascospore *53169* Douglas fir, Potowomut.

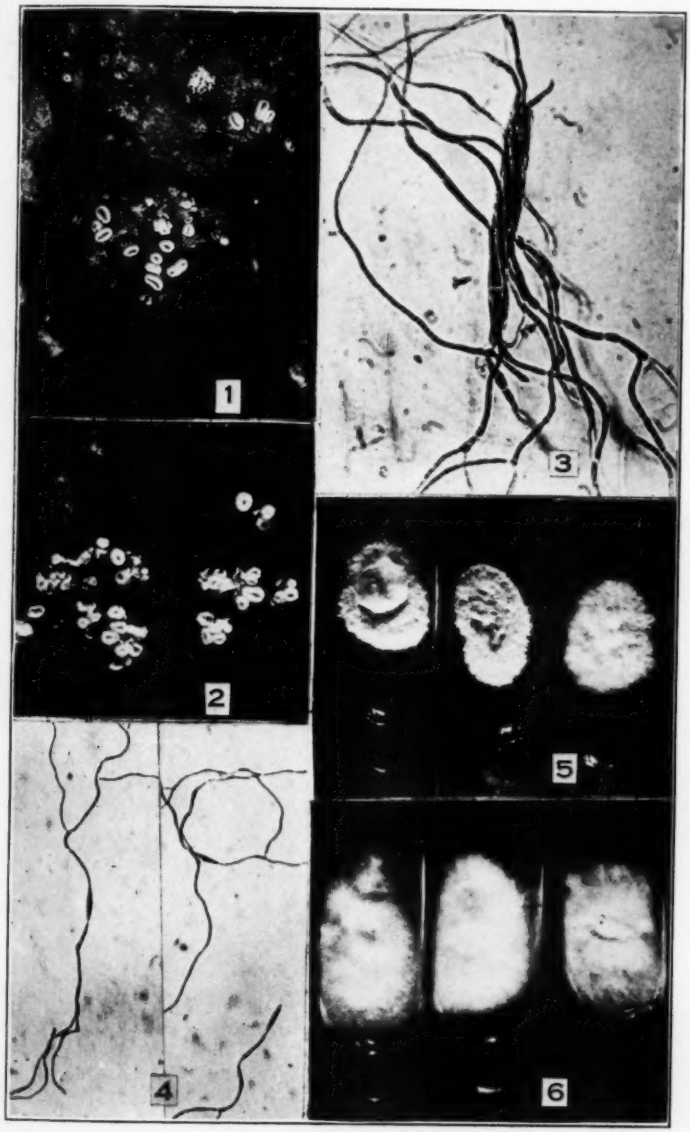
Lachnum lachnoderma (Berk.) Hahn & Ayers

Fig. 8, Excipular hairs; 9, Asci and paraphyses; 10, Ascospores.

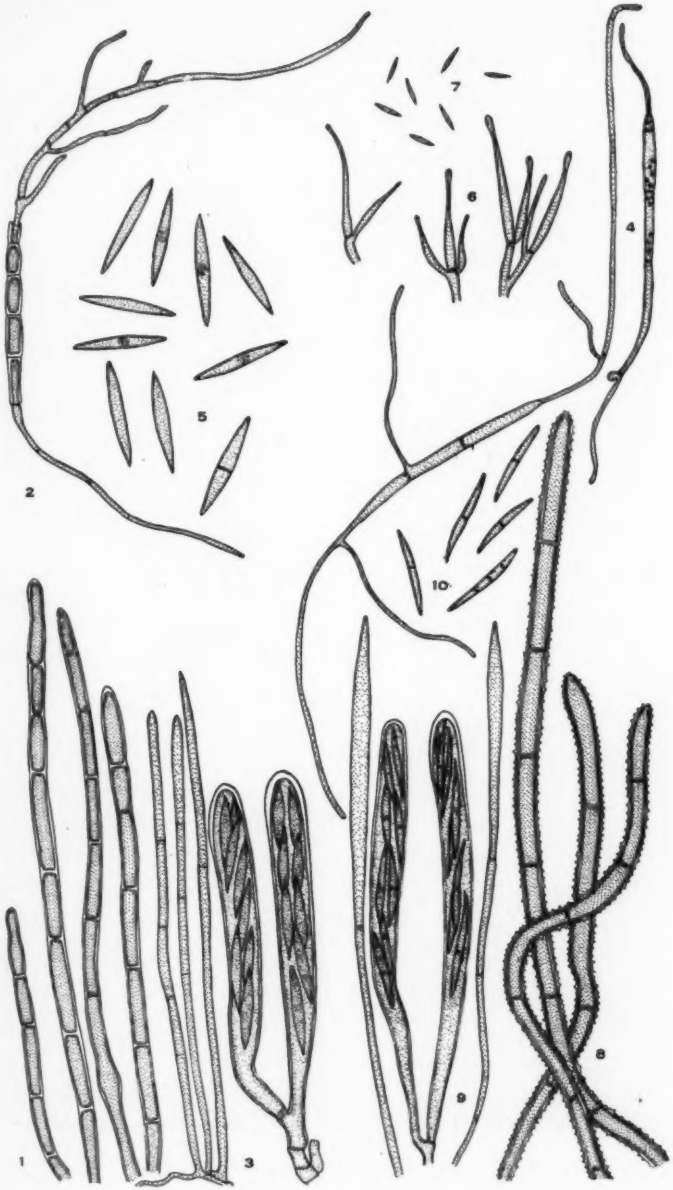
EXPLANATION OF PLATE 23

Dasyscypha Ellisiana

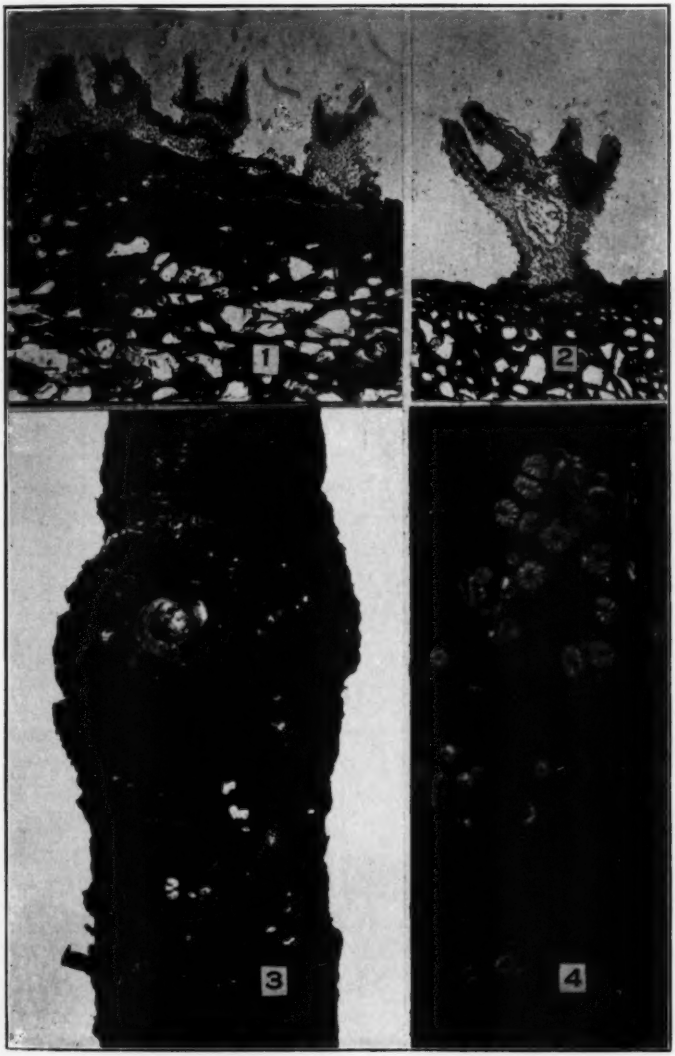
Fig. 1, Longisection of stromata of the imperfect stage showing simple cavities widely distended. × 65; 2, Longisection of compound stroma of the imperfect stage. × 65; 3, Diseased branch Douglas fir, Potowomut, R. I. material, showing cankered swollen base with fruit bodies on surface of hypertrophied bark. A virulent strain of the fungus, which produced the toxin peculiar to the fungus, was isolated from tissues of this canker. Approx. × 3; 4, Habit, over-mature apothecia showing disintegrating cups, the hymenia of which are disappearing (Potowomut, R. I. Douglas fir material, *43587*). Approx. × 8.5.



DASYSCYPHA ELLISIANA



1–7. DASYSCYPHA ELLISIANA
8–10. LACHNUM LACHNODERMA



DASYSCYPHA ELLISIANA

GYMNOSPORANGIUM MYRICATUM IN RELATION TO HOST PARENCHYMA STRANDS [1]

B. O. Dodge

(WITH PLATES 24 AND 25 AND 2 TEXT FIGURES)

Some of the effects of the bayberry rust, *Gymnosporangium myricatum*, on the southern white cedar, *Chamaecyparis thyoides*, were noted in a recent number of the Journal of The New York Botanical Garden [2] where photographs of two trees that had died prematurely from severe infections were shown. Such illustrations are proof that species of this rust genus can, on occasion, be very destructive to the cedar hosts. When one follows the path taken by the fungus in each case as it invades the cedar host he understands why the abnormal growths produced are sufficiently characteristic to be specifically diagnostic in most cases.

Some years ago Wörnle [3] made a study of several species of *Gymnosporangium* from the standpoint of the forester. He was particularly interested in finding out what host tissues were invaded by the parasite. One of the species studied he referred to as *G. juniperinum* on the branches and trunk. This comes the nearest to what I find for *G. myricatum* in the way it attacks its cedar host, and the histological picture he draws of the effects of *G. juniperinum* represents fairly well what one would find in examining *Chamaecyparis* infected with our species. Wörnle also made a superficial study of *G. myricatum* (*G. Ellisii*) from a single small branch, but he could not have hoped to learn many of the details from this small amount of dried material. He noted certain brown patches in the wood and cortex which contained hyphae. The hyphae, he said, were very coarse, having a diameter

[1] Studies in the genus *Gymnosporangium*—IX.

[2] Jour. N. Y. Bot. Gard. **35**: 41–45. 1934.

[3] Wörnle, P. Anatomische Untersuchung der durch Gymnosporangium-Arten hervorgerufenen Missbildungen. Forst. Nat. Zeits. **3**: 68–84; 129–172. 1894.

of 8 μ. Hyphae of the European species he found were very much finer.

As noted in an earlier publication,[4] a few telial sori develop on leaves the first spring after inoculation, but it commonly requires about 20 months. Sori first appear directly on leaf blades or on the youngest branches that are not yet covered with cork layers. The mycelium is found throughout the spongy parenchyma of the leaf beneath the sorus, and in the cortex of the young branch. Just as in all other species studied, the terminal cells of the young

Fig. 1. Section of young *Chamaecyparis* stem infected with *Gymnosporangium myricatum*. The gaps in the wood ring occupied by thin-walled parenchyma cells accompanied by hyphal strands. Infection originally at about this point or at the time when the tip was at this point.

sorus primordium swell and elongate to make a buffer tissue to break up the overlying epidermis. Teliospores arise from subterminal cells. The necessity for such a buffer tissue is more apparent when sori in later years develop on branches or on the main trunk and are, therefore, overlaid with tough bark.

Whenever the sori break out on the trunk of a tree near the base, one may be unable to account for the appearance of the fungus on such old parts. Wörnle, in referring to the peculiar distribution of mycelia of *G. juniperinum*, suggested that the

[4] Studies in the genus *Gymnosporangium*—II. Report of cultures made in 1915 and 1916. Bull. Torrey Club **45**: 287–300. 1918.

fungus originally entered the branch or trunk through the dormant buds, "schlafende augen" he called them, or through shoots because they seem to afford the only line of communication between the outside and the inner tissues now showing mycelial hyphae. This may be true in some cases, but it is more than likely that whenever the main trunk shows infection in later years the fungus originally gained entrance at the time when this part was the tip end of the main axis. If the mycelium ran down from an infected branch at that point, one should find remains of the branch still containing hyphae. Study of many southern white cedars infected with *G. myricatum* shows that the green tip of the main axis may become infected directly through the leaves at a time when this part is not covered with cork layers. In sections of a small infected stem, for example (PLATE 24, *A*) one sees gaps in the ring wood now occupied by thin-walled parenchyma cells containing haustoria. Hyphae penetrate to the very center of the twig as shown in text figure 1. As the twig grows the fungus tends to progress vertically and radially in fascicles, leaving portions of the cortex parenchyma entirely free (PLATE 25, *D*). There are many cells still capable of division distributed here and there all through the bark parenchyma. Such cells can become functional cambium and thus give rise to tracheids, which in turn cut off or surround the parenchyma strands carrying the fungus. The small picture (PLATE 24, *A*) shows, upper left, a cross section of two vertically growing parenchyma strands about to be walled in by new wood. At the right in the same figure there is shown such a strand only recently completely walled in.

Sections of a young tree show the phloem region in which the cells are more or less radially arranged, and stereome or lignified cells disposed in open rings. Such lignified cells are also distributed sparsely and rather irregularly throughout the cortex or bark parenchyma. The cells of the medullary rays, which soon collapse in the wood rings, are very conspicuous in the cortex, retaining their cytoplasmic and nuclear contents. While in cross sections one sees a great many cells of the cortex which appear to be more or less lifeless because they are somewhat collapsed and irregular, nevertheless many of them still contain nuclei and some cytoplasm and are thus capable of being rejuvenated.

Whenever a hypha advances in the vicinity of any of these medullary ray cells or any other cortex cells still possessing nuclei, such cells are rejuvenated. They become more turgid and swollen, and the nuclei are more conspicuous. After the nuclei divide, thin walls cut across the cell as though by internal division, the old

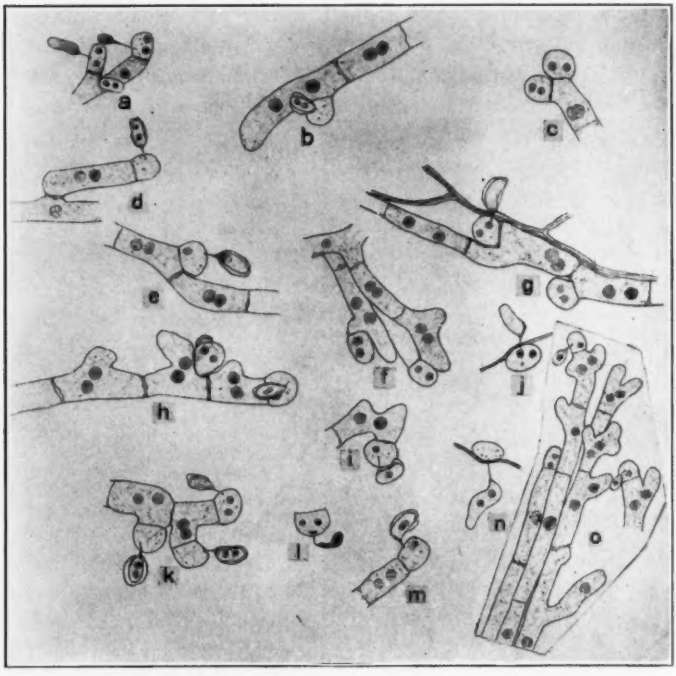


Fig. 2. Various stages in the formation of haustoria and the migration of the nuclei from the mother-cell to the haustorium. The host parenchyma cells invaded are not shown. See text for further discussion.

wall remaining intact. When a number of parenchyma cells are thus stimulated to increase in size and to divide, pressure is exerted on the neighboring cells which are forced aside or pressed together (PLATE 24, *C, D*). This gives us the picture of a parenchyma strand burrowing into the cortex, as it were, like a cancerous growth. Furthermore, one finds cases where stimulated cortex

cells multiply and add entirely new cells at the terminus of the parenchyma strand, thus simulating even more closely an invading growth.

Haustoria penetrate cells without seeming to have any deleterious effect. When a red cedar becomes infected by *G. germinale,* cells bordering the hyphae, especially cells invaded by haustoria, soon show much disorganization. *G. myricatum* has quite the opposite effect, since cell life is prolonged and rejuvenated. As the branch increases in length the fungus also grows upward as well as downward, always keeping the hyphae grouped in synemata so that sections show the parenchyma strands in different aspects depending on where the sections are made. The condition illustrated in PLATE 25, *C* would suggest that the strands had pressed the tracheids aside with great force. The true explanation is that the strands were there before the wood was laid down. Pressure was exerted on all sides of the cells about to become lignified and this kept them oriented in the way we now find them. The cells of the parenchyma strands elongate in the direction taken by the bordering hyphae and maintain life for a long time even after being surrounded by wood tissue. Cells of hyphae imbedded in three or four wood rings may still show their two nuclei plainly. Usually, however, the cytoplasm and nuclei of infected cells degenerate after the second year and the parenchyma strands turn brown (PLATE 25, *B*). Hyphal growth must be slow. Tip ends of radially growing hyphae are very conspicuous as they emerge from the wood ring and appear to be growing into the cortex (PLATE 24, *A*). No matter what the section picture of strands isolated in the wood cylinder may be, any strand, if followed up in serial sections, must invariably lead to the cortex, because the hyphae originally came in through the cortex or from the growing region in case of tip end infections before differentiation of the wood cylinder. Wherever a hypha grows, sending haustoria into the adjacent cells, it prevents those cells from differentiating sufficiently to become normal tracheids. So we have these parenchyma strands always accompanied by hyphae. The stimulus may extend to cells in the vicinity which are not touched or bordered by hyphae.

As noted previously, the hyphae of this species are comparatively coarse and have a peculiar way of branching (TEXT FIG. 2). Each cell contains two large nuclei. No other species studied has such large haustorium mother-cells. They show fairly well even in a photograph (PLATE 24, *F*). They are usually formed terminally and the subterminal cell branches out at an abrupt angle to continue onward growth. This suggests the method by which conidia of *Phytophthora* are formed. They may appear to be lateral, but they were formed terminally. The mother-cells always contain two small nuclei at first (TEXT FIG. 2).

An infected plant that had been kept in the cold frame until December 1 was brought into the greenhouse. Sections of the stem at the point of infection made two weeks later showed haustoria in all stages of development as though the fungus had just begun to invade these regions. Young haustoria were more numerous in the cortex, but they were also present in parenchyma strand cells well imbedded in wood rings. Very likely these began their development a year or two previously, and not just recently, but the nuclei were unable to pass out from the mother-cell. Perhaps a haustorium can function very well for a time without a nucleus. Dead haustoria such as shown in text figure 2, *l*, are not common. Here the haustorium is shrunken, and one sees plainly a thickened pad on the wall of the mother-cell at the point where the thread is attached. Stages like that shown in text figure 2, *j*, where the nucleole seems to have been left behind while the nucleus is spinning out to pass through the haustorium thread, are rather common. A later stage is shown at *e*. The nucleus has just reached the haustorium and stains very deeply, the nuclear membrane not being at all conspicuous. Many haustoria that appear to be fully mature show only one nucleus (TEXT FIG. 2, *m*). In this case the other nucleus is always found back in the mother-cell. When a haustorium shows two nuclei one often finds two small deeply staining specks in the mother-cell (TEXT FIG. 2, *k*), with an open space around each. If this were the size of the nucleus one might think that it represents the region originally occupied by the mother-cell nucleus and the deeply staining speck would represent the nucleole. The vacuole is much larger than the nucleus, however, and the specks are not always very definite.

There is no conspicuous swelling of the host cell wall at the point of penetration (TEXT FIG. 2, *g*). The haustorial thread is very fine, scarcely visible at the point where it passes through the host cell wall. It gradually widens and swells out at the outer end, as shown in text figure 2, *a*. As the haustorium elongates it increases in size toward the mother-cell. There is no ring or cup at the base of the haustorium such as one sees so conspicuously in *Diplocarpon Rosae*.[5]

Just what may be the nature of the so-called haustorium sheath is a question here as elsewhere. Young haustoria without nuclei seldom show any sheath, and some old haustoria do not. Usually, however, one can make out very distinctly a hyaline region bordered by a very distinct line surrounding the haustorium. This is usually more or less irregular. It seems to be attached to the haustorial thread at its outer extremity or the point where it connects with the body part.

The size of the haustorium of *G. myricatum* varies somewhat, but it is no larger when found in the cortex of a tree trunk than when it occurs in the spongy parenchyma of the leaf. The large haustorium (TEXT FIG. 2, *n*) was from a leaf cell. This point is important because there is a question whether one of the leaf infecting forms of *Gymnosporangium* on *Chamaecyparis*, the form I have previously but erroneously referred to as *G. fraternum*, may not be merely a leaf form of *G. Botryapites*. Only infection experiments would settle this question. I was never able to infect *Chamaecyparis* with either the leaf form or the stem form, using spores from aecia on *Amelanchier* leaves, aecia which would pass as belonging to *Roestelia Botryapites*. These aecia were obtained in the one case by sowing spores from telia of the leaf form, the one erroneously referred to as *G. fraternum*, and in the other case by sowing spores from telia of the stem form *G. Botryapites*. None of the sowings of the aeciospores on the *Chamaecyparis* gave telia, either of leaf form or the stem form. This is not strange because very few persons have ever been able to infect the cedars with *Gymnosporangium* species. In spite of this lack of proof, however, by studying the haustoria of the leaf infecting form and com-

[5] Dodge, B. O. A further study of the morphology and life history of the rose black spot fungus. Mycologia **23**: 446–462. 1931.

paring these with haustoria found in the cortex of the stem infecting form, one sees that there is considerable difference, although in shape and number in a cell they are very much alike. In both forms it is not uncommon to find as many as six or eight haustoria in one cell. In both forms they are rather blunt and chubby. They differ, however, considerably in size, those of the stem form being much larger. Whether the change in tissues attacked would be followed by corresponding changes in the size of the haustoria is very doubtful. The haustoria of *G. Juniperi-virginianae,* where they are found in very large gall cells, are themselves very small, in fact the smallest haustoria I have found in the genus *Gymnosporangium,* and, as noted above, the haustoria of *G. myricatum* when found in the leaf cells are just as large as those found in the cells of the branches or trunks.

G. juniperinum and *G. myricatum* are much alike, as noted previously, in the way their mycelia are distributed among the host tissues. According to Wörnle's cross section diagram of the former species, the parenchyma strands run out radially, while they may run in any direction in case of the latter species. It has been found that the histological picture of the host parasite relation and the morphology of the haustorium furnish together a valuable addition to the diagnostic features which may be useful in distinguishing species of the genus *Gymnosporangium.*

SUMMARY

The mycelium of *Gymnosporangium myricatum* penetrates the cortex parenchyma of *Chamaecyparis* near the growing region and runs along vertically or radially between the host cells in synemeta. Each hyphal cell contains two large nuclei. Binucleate haustorium mother-cells are usually formed terminally, the subterminal cell branching out to continue the growth.

A thin haustorial thread penetrates the wall of the host cell continuing on into the cytoplasm for some distance before swelling up to form the haustorium. This grows to nearly its full size without a nucleus. The nuclei from the mother-cell spin out through the thread, one following the other after a rather long interval. While many haustoria function for a time without any

nucleus, eventually a mature haustorium contains two nuclei and the haustorium mother-cell none.

Parenchyma or medullary ray cells adjacent to hyphae are stimulated to enlarge and divide. From this there results a sort of parenchyma strand. Four or five daughter cells are often enclosed within the old wall of the original cell, the daughter cells separated merely by thin membranes. New cells may be added on at the end of a strand. The pressure exerted by this forward growth of the strand often crushes the opposing cortex cells, so that there is a certain amount of invasion of cortex by a "growth." In general, however, the strand is mainly made up of cells that have been rejuvenated by the presence of the fungus. Sections of branches killed by the fungus show the remains of the strands as brown patches or streaks.

Young seedlings or branches infected in the growing region are apt to be permanently dwarfed and die early. Large trees bearing many witches' brooms may die prematurely.

The parenchyma strands never *invade* the wood rings. If found there, it means that they were captured by the wood laid down around them. The reaction of the host to the stimulus coming from these invading hyphae, and the morphology of the haustoria and their mother-cells are rather characteristic for each species of the genus and thus furnish additional clues for identification purposes.

THE NEW YORK BOTANICAL GARDEN

EXPLANATION OF PLATES

Gymnosporangium myricatum on *Chamaecyparis*

PLATE 24

A. Cross section showing a fan-shaped parenchyma strand with accompanying hyphae. The size of the hyphae is apparent from the way they show in the photograph which is not highly enlarged. At the inner end or vertex of the strand and connected with it there is seen an irregular patch of parenchyma tissue. Here the strand extends vertically so that the cut ends of hyphae as well as of the long parenchyma cells give the spot a different aspect. Where a strand is growing vertically in the phloem region it will eventually be captured and surrounded by tracheids, as shown by the whitish patches at the border of the wood cylinder.

B. Section of a dwarfed tree about 17 years old. The first ten rings are normal and show no patches with hyphae. These appear in the eleventh

ring in this section. Some distortion of the twelfth to fourteenth rings is evident. Farther up or down some section might have shown the fungus at the very center (see text fig. 1). The long radial streak represents a parenchyma strand with accompanying hyphae.

C. Parenchyma strand from the wood cylinder invading the phloem and cortex parenchyma.

D. More highly magnified picture of the outer portion showing thin-walled parenchyma cells of the strand containing conspicuous nuclei.

E. A still more highly magnified section of the outer end of a similar strand showing hyphae bordering large parenchyma cells. Note the thin walls laid across these large cells cutting them up into segments, each with its nucleus. The original wall encloses the three or four daughter cells. The crushing effect on the cortex parenchyma by the invading strand is evident here.

F. Portion of a radial strand under oil immersion lens at the border of the wood cylinder. Haustorium mother-cells with their two nuclei are conspicuous. Abnormal tracheids, lower right. Note also how the parenchyma cells elongate in the direction taken by the adjacent hyphae.

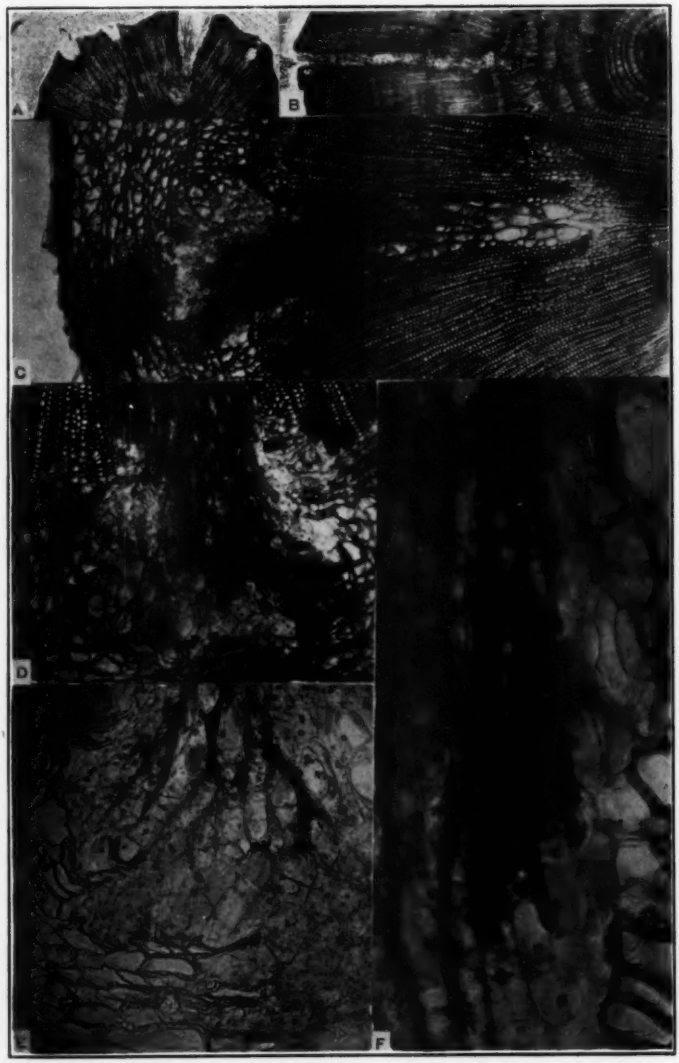
PLATE 25

A. Longitudinal radial section showing an oblique section of a parenchyma strand. Note that the wood cells have abnormal ends where they touch the strand.

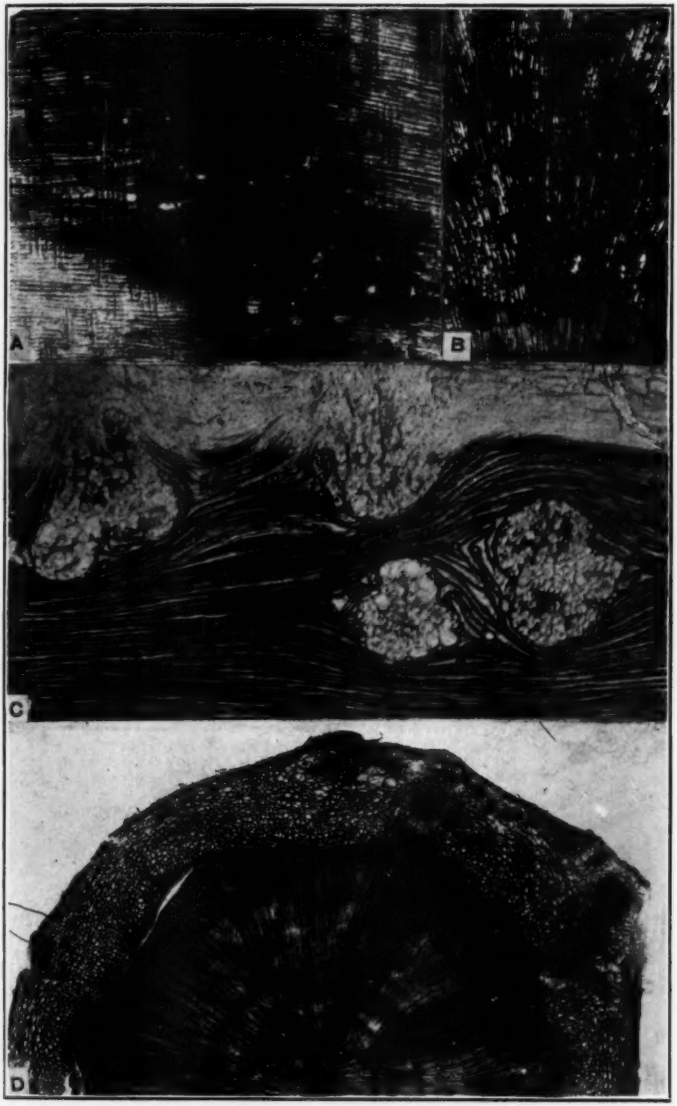
B. Cross section showing brown pockets in wood rings occupied by the fungus.

C. Tangential section showing cut ends of parenchyma strands in the wood rings, also parts of radially growing strands in the cortex. These strands were present before the tracheids, which now appear to be under great pressure. They were simply forced to take up their present positions as they were built up around the strands.

D. Cross section showing two radially growing parenchyma strands. Several vertically growing cortex strands are cut across. The black spot in the cortex at right center represents one of Wörnle's "schlafende augen" or dormant buds. No hyphae were found associated with this one.



GYMNOSPORANGIUM MYRICATUM



GYMNOSPORANGIUM MYRICATUM

NOTES AND BRIEF ARTICLES

Mycologia Endowment Fund

On May 11, 1933 the Managing Editor received a check for one thousand dollars ($1000.00) from one who wishes to be referred to merely as "a friend of MYCOLOGIA." At the suggestion of the Managing Editor this was accepted by the Board of Managers of The New York Botanical Garden and set apart as the nucleus of an endowment fund with the following resolution:

"RESOLVED, that the gift of $1,000 from an anonymous donor be accepted, subject to the provisions of confidential letter on file with the Secretary, and the Director is hereby instructed to express the very sincere thanks of the Executive Committee to the very generous contributor.
RESOLVED FURTHER, that the gift of $1,000, referred to in the above minute, be added to the restricted endowment funds, the income only to be used for the support of MYCOLOGIA."

It is expected that this fund will be added to from time to time either by private donation or funds from the sale of back sets published previous to 1933. Added contributions are solicited.

PHYTOPATHOLOGICAL CLASSICS

Under the above title the American Phytopathological Society is publishing a series of papers, three of which have already been issued as follows:

1. Fabricius. Attempt at a dissertation on the diseases of plants. 1774. Translated from the Danish by Mrs. Margaret Kølpin Ravn.
2. Fontana. Observations on the rust of grain. 1767. Translated from the Italian by P. P. Pirone.
3. Millardet. The discovery of Bordeaux mixture. Three papers. 1885. Translated from the French by F. J. Schneiderhan.

These may be had at fifty cents each or for a limited period at one dollar and twenty-five cents for the three. Application should be made to H. H. Whetzel, Cornell University, Ithaca, New York. Other numbers are in course of preparation.

A NOTE ON MYCOLOGY IN BRAZIL TODAY

Stationed at the Agricultural College of the State of Minas Gerais, Brazil, during the last four years, the writer of this note had occasion to meet various Brazilian mycologists, and had access to numerous agricultural and scientific publications of Brazil today.

Perhaps the most prolific author during that time has been Padre João Rick, of Porto Alegre, Rio Grande do Sul, who has published in almost every number of the journal *Egatea*, volumes 14–18, on the Basidiomycetes, particularly the Hymenomycetes. There have appeared, under his authorship, lists, including diagnoses of many new species of fungi collected in that state belonging to the following families: Thelephoraceae, Hydnaceae, Lycoperdaceae, Nidulariaceae, Phallaceae, and Hymenogastraceae. Monographic studies have appeared on *Agaricus*, *Boletus*, and *Helvella*, by the same author in the Portuguese journal, *Broteria*.

Three mycologists, collectors over a period of some thirty years in eastern central Brazil, and possessors of excellent private herbaria are Drs. Eugenio Rangel, Arsene Puttemans, and Rosario Averna-Sacca, and they are still active. Padre C. Torrend, collector of Basidiomycetes, is Brazil's northernmost mycologist.

Drs. Heitor Silvevio Grillo and Ageslau Bitancourt are two young Brazilian scientists, who, trained in mycology, are transferring their efforts at present more to the study and control of plant diseases and to the development of this science in Federal and State Agricultural Departments. These workers are greatly desirous of contacts and of exchanging material and information with colleagues in other lands, as is the writer who continues as mycologist and plant pathologist at the College at Vicosa, Minas Gerais, Brazil.

ALBERT S. MÜLLER

PILOBOLUS CRYSTALLINUS IN PURE CULTURE

Ordinarily *Pilobolus crystallinus* (Wiggers) Tode has been grown in the laboratory only upon its natural substratum, *i.e.* the dung of herbivorous animals. Only recently an artificial medium has been used for its cultivation. On April 14, 1933 [1] the writer

[1] Annual meeting of The Arkansas Academy of Science.

presented an account of his culture of this fungus on a dung agar. This agar was prepared as follows:

"Boil 300 gms. fresh sheep dung in a liter of distilled water until the dung is broken down. Filter. Restore liquid to its original volume. Add 15 gms. agar agar shreds. When agar is melted place in 250 cc. Erlenmeyer flasks. Autoclave for 15 min. at 15 lbs. pressure. Slant flasks to obtain maximum surface of the agar."

No difficulty was encountered in securing pure cultures from single sporangia, or from sporangiophores with sporangia attached. The surface of such flasks became covered with characteristic fruiting structures which were discharged in the normal way. The glass on the side of the flask opposite the slanted surface was very closely dotted with the discharged sporangia. A culture prepared in November, 1932 which began to discharge sporangia December 1, 1932 is still discharging sporangia, but in considerably less numbers on May 8, 1933.

Pilobolus crystallinus has also been grown on a beef extract agar which may be prepared as follows: "Boil 210 gms. boiling beef vigorously in a liter of distilled water until the meat is thoroughly cooked. Strain the broth through several thicknesses of cheese cloth. Restore to original volume and make agar as described above."

Transfers made from a dung agar culture to a flask of this beef agar on April 30, 1933 produced the first crop of sporangia on May 5, 1933. The fungus is quite readily adaptable to this medium and thrives quite well. Subcultures made from such cultures continue to grow and produce normal sporangia. In older cultures many of the sporangia are not discharged with as much force as they are in younger cultures. In previously prepared cultures, now three months old, sporangia are still being produced, although they are not being discharged so violently.

From these results it is evident that:

1. It is unnecessary for spores of *Pilobolus crystallinus* to pass through the digestive tract of an animal before germinating.

2. *Pilobolus crystallinus* may be easily cultured in pure culture on an ordinary dung decoction agar without any involved treatment.

3. *Pilobolus crystallinus* may be grown for several successive generations on artificial media at ordinary laboratory temperatures.

4. This fungus has been grown in the laboratory on a beef decoction agar, and has thrived for some time.

DELBERT SWARTZ

UNIVERSITY OF ARKANSAS

MUSHROOM POISONING AT SEATTLE

The popular and widespread interest in mushrooms around the Puget Sound region has gradually increased from year to year until now it has become almost phenomenal. Whether this interest has been augmented by the present depression it is hard to say. From the time the rains start in the fall until the frost comes there is an ever-increasing interest. Usually the spring is less favorable for the growth of mushrooms in this region but owing to the wet and late spring this year (1933) there was a more than usual interest exhibited.

This mushroom gathering was not entirely free from unpleasant incidents. At times some over-enthusiastic or careless collectors made rather serious mistakes in their identification of edible species. Eight cases of mushroom poisoning caused from eating *Amanita pantherina* Fries have recently come under my notice. This species was first reported for the United States in 1929 by Zeller who found it rather abundantly in the spring in Oregon. He also reports several cases of mushroom poisoning as a result of eating this species. The following report emphasizes his findings.

Early in May, in the vicinity of Anacortes, Washington, two people, Mr. and Mrs. R., aged about 35, both in fine physical condition, prepared specimens of *A. pantherina* in the usual way and ate them at noon. In less than an hour both became very dizzy and felt weak and sick. A neighbor drove them immediately to a physician. By this time the woman had collapsed and the man showed inability to coördinate, acting as if drunk. The physician sent me the following statement: "The patients were immediately taken to the hospital, the woman rapidly losing consciousness and developed spasmodic jerkings of her whole body. Both had subnormal temperatures, dilated pupils and pulse as low as forty. The woman became quite violent, dizziness and inability to think

seemed to be the most pronounced symptoms. There was no pain, colic, etc. at any time. The treatment was as follows: A pint of permanganate of potash solution was immediately given, followed by one-tenth grain of apomorphine, then one-fiftieth of a grain of atropin. Following emesis and complete cleaning out of the stomach, each was given one ounce of castor oil and as soon as this worked they were given one-quarter grain of morphine and one-fiftieth grain of atropin. During all this eliminative treatment each was given a teaspoonful of a solution consisting of ten drops tincture agaricus muscaris in a half glass of water, every half hour. The man did not lose consciousness but lay in a semi-comatose condition for several hours. The woman regained consciousness in about eight hours. By the next morning both appeared normal and were sent home, and the following day they were practically recovered except that they were both very weak."

A little later in May two other persons, Mr. and Mrs. S. found the same species which had been collected by some one and left by the roadside. Believing these to be discarded mushrooms they were taken home, cooked and eaten with much the same results. The man, however, had a weak heart which could not withstand the extra work put upon it. He died. The woman survived.

About two weeks later four other Seattle residents driving out in the country one Sunday afternoon collected what they believed to be edible mushrooms but they proved to be *A. pantherina*. All four were taken violently ill with much the same symptoms as those described for the two at Anacortes. After a few days illness all four recovered.

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MYCOLOGICAL SOCIETY OF AMERICA

REPORT OF THE HIGHLANDS FORAY

The Mycological Society of America, at its foray in August, 1933, voted that a list of species taken by each collector should be filed with the Highlands Museum and Biological Laboratory, and that these records would form the basis of a report, here published.

The total number of named species collected during the three days of the foray is 430, distributed in groups as follows: Agaricaceae, 156; Ascomycetes, 85; Polyporaceae, 47; Thelephoraceae, 39; Fungi Imperfecti, 24; Uredinales, 17; Gasteromycetes, 15; Hydnaceae, 15; Boletaceae, 14; all others, 18. Several other species collected await determination. Some of these, it now appears, are new to science.

A considerable proportion of the species found are of rather general occurrence and are therefore omitted from this notice. On the other hand, several collections are of interest; some have not previously been reported from North America, and others, according to published records, are rare or limited in their range.

MYXOMYCETES.—*Cribraria microcarpa* (Schrad.) Pers., *Arcyria pomiformis* (Leers) Rost., *Echinostelium minutum* deBary., *Hymenobolina parasitica* Zukal.

ASCOMYCETES.—*Thelebolus lignicola* Lloyd, *Elvela atra* Oed., *Calicium polyporaeum* Nyl, *Balansia Hypoxylon* (Peck) Atk., *Bombardia fasciculata* Fries, *Cordyceps clavulata* (Schw.) Ellis & Ev., *Hypoxylon regale* Morgan, *H. serpens* var. *macrospora* Mill., *Rosellinia Clavariae* on (Desm.) Tul. on *Clavaria cristata* (Holmsk.) Fries, *Scoleconectria scolecospora* (Bref.) Seaver, *Xylaria ianthino-velutina* Mont.

FUNGI IMPERFECTI.—*Sepedonium brunneum* Peck, *Toxosporium abietinum* Vuill., *Gonatobotryum maculicolum* (Wint.) Sacc.

UREDINALES.—*Puccinia Acetosae* Körn.

TREMELLALES.—*Tremella* (*Naematelia*) *aurantia* (Schw.) Burt.

THELEPHORACEAE.—*Aleurodiscus apiculatus* Burt, *Corticium byssinum* (Karst.) Massee, *C. confusum* Bourd. & Galz., *C.* (*Botryobasidium*) *coronatum* (Schröt.) v. Höhn. & Litsch, *C. subcoronatum* v. Höhn. & Litsch, *C. tulasnelloideum* v. Höhn. & Litsch, *Peniophora attenuata* Bourd. & Galz., *P. pallidula* Bres., *Septobasidium pinicola* Snell, *Stereum burtianum* Peck, *S. Murrayi* (Berk. & Curt.) Burt, *S. pallidum* (Schw.) Lloyd, *Thelephora albido-brunnea* Schw., *Tremellodendron cladonia* (Schw.) Burt.

HYDNACEAE.—*Odontia cristulata* Fries.

POLYPORACEAE.—*Polyporus balsameus* Peck, *P. fragilis* Fries, *P. graveolens* Schw., *P. Montagnei* Fries, *P. Pes-caprae* (Pers.)

Fries (=*P. retipes* Underw.), *P. poculus* Schw., *Solenia fasciculata* (Pers.) Fries.

BOLETACEAE.—*Boletus cyanescens* (Bull.) Fries, *B. parasiticus* (Bull.) Fries.

AGARICACEAE.—*Amanita spreta* Peck var. *parva* Beardslee, *Armillaria* (*Pleurotus*) *corticata* Fries, *Cantharellus floccosus* Schw., *C. infundibuliformis* (Scop.) Fries, *C. tubaeformis* Fries, *Clitopilus abortivus* Berk. & Curt., *Cortinarius largus* Fries, *Crepidotus stipitatus* Kauff., *Inocybe agglutinata* Peck, *I. decipientoides* Peck, *I. leptocystis* Atk., *I. prominens* Kauff., *I. umbrinella* Bres., *Lactarius atroviridis* Peck, *L. mucidus* Burl., *L. peckii* Burl., *Leptonia lampropoda* Fries, *L. subserrulata* Peck, *Panus laevis* Berk. & Curt., *Pleurotus atropellitis* Peck, *Russula aeruginea* Lindbl., *Tricholoma decorosum* Peck, *T. leucocephaloides* Peck, *T. portentosum* Fries var. *centrale* Peck, *T. subsejunctum* Peck, *T. transmutans* Peck.

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REPORT OF THE SECOND ANNUAL MEETING

The second annual mid-winter meeting of the Mycological Society of America was held December 28, 29, and 30, at Boston, Massachusetts, in conjunction with that of the American Association for the Advancement of Science. The Society headquarters were at the Hotel Westminster on Copley Square in Boston. The sessions were held at Harvard University in Cambridge. The meeting was well attended, and, though hindered somewhat by extremely inclement weather, will be remembered as a pleasant and profitable one. The local arrangements made for us by Doctor Weston were most satisfactory. The retiring president, C. L. Shear, presided at the sessions, and, at the close of the business meeting on Thursday, addressed the Society. His paper, entitled "Mycology, Scientific and Otherwise," will appear in the next issue of MYCOLOGIA. The Society held joint sessions with Section G and the American Phytopathological Society. Saturday afternoon was given to the making of demonstrations of research mate-

rials and to the explanation of mycological exhibits set up earlier in the week by members of the Society.

At the business session on Thursday, reports by the secretary-treasurer and managing-editor of MYCOLOGIA showed the Society and its journal to be in satisfactory financial condition. New officers elected for 1934 are Herbert S. Jackson, president; Bernard O. Dodge, vice-president; and Lee O. Overholts, councilor. The council named G. W. Martin to succeed H. M. Fitzpatrick on the editorial board of MYCOLOGIA. The editor-in-chief, F. J. Seaver, reported that the board had voted unanimously against the printing of abstracts of papers presented at the meetings. This action was accepted as final disposition of the matter. The amendments to the constitution submitted to the membership by mail in November were adopted. One of these empowers the council to name a Society Historian. As yet the position has not been filled.

At the regular sessions approximately thirty-five papers were presented, dealing with many groups and phases of mycology. The prominence of contributions on the Phycomycetes, noted last year at Atlantic City, was again evident. An increase in interest in the field of medical mycology was indicated. Papers on aspects of sexuality in Ascomycetes and Basidiomycetes were outstanding. A paper by S. M. Zeller, not received in time for inclusion in the printed program, was read on Thursday, the title being "Protogaster, a representative of a new order of Gastromycetes." A brief discussion was given by J. C. Arthur of his Manual of Rusts, now in press. Doctor Arthur was introduced at the Botanists' Dinner as the "Dean of American Botany," and was most cordially received. He was also retiring president of the American Phytopathological Society.

The council approved the printing of an address list of our members. This will be prepared and mailed as soon as the necessary data are available. Those who have not yet returned the blank provided for this material are urged to forward it promptly. An increase in our membership is desirable. All persons interested in mycology are eligible and are invited to join. At present the roll consists of approximately three hundred and fifteen names.

A detailed statement of all receipts and expenditures accompanied by vouchers was submitted to the council. This was audited and approved. The auditing committee, named by the president, consisted of H. S. Jackson, chairman, Neil Stevens, and L. Leonian.

H. M. FITZPATRICK, *Secretary-Treasurer*